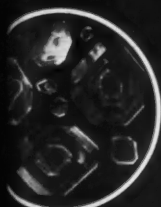
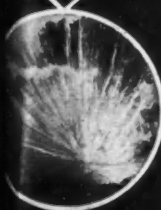


CHEMISTRY



MAY
1946



ARTICLES YOU CAN UNDERSTAND

Americium and Curium.....	1
The Atomic Nucleus.....	13
Radioactive Antimony.....	17
For the Home Lab:	
Isolation of Boron.....	19
Highlights From A.A.S. Meeting.....	21
Rocket Patents and Other Inventions.....	24
Atomic Energy Plant Operation.....	28
Chem Quiz:	
Where Do Elements Get Their Names?....	31
Aid For Young Scientists.....	32
Spitfire At Work.....	33
Too Much Security.....	35
Chemical Things To Do:	
Write With Beam of Light.....	37
International Control of Atomic Energy II.....	39
Glass Transmits More Light.....	56
Back Cover Picture: More Light	
New Electron Microscope Tricks.....	61
Editorial:	
Denatured Plutonium.....	
Inside Front Cover	

25¢

Denatured Plutonium

➤ ANOTHER MAJOR SECRET has been added to the world's lack of information about the atomic bomb. This is the nature of the denaturing material used to make uranium 235 or plutonium incapable of being turned into an explosive bomb. This contaminating material is something that has been known about for several years during atomic research. Its possible use in solving the difficulties of making atomic bomb materials available to the world was announced in the State Department's report on the international control of atomic energy. Its removal from the denatured fissionable material would take a large and lengthy manufacturing operation. The State Department committee report lifts slightly some of the secrecy surrounding atomic fission and atom splitting, but the scientific world still lacks data that in the normal course of peacetime science would be published for the world to know.

Most interesting is that plutonium can be "denatured." It could be guessed as to how this could be done, and later it was made known that the plutonium that fissions explosively could be so contaminated with another non-fissionable isotope of the same element that it could not be exploded.

Unless the plutonium is sufficiently pure and undiluted by extraneous materials, there will not be enough neutrons to produce the violent and extremely fast-chain reaction of the atomic bomb explosion. Each splitting plutonium atom gives out from one to three neutrons, but these must have the chance to reach other fissionable plutonium atoms in a very short space of time without being absorbed and made useless for that purpose.

Many kinds of materials can produce this necessary dilution, but the point in control of plutonium if it were distributed for peaceful power producing uses is that the diluting or denaturing material must be very difficult to separate from the fissionable material. Otherwise a few chemically-wise international gangsters might take improperly denatured plutonium and turn it into purified fissionable plutonium and the first the world would know about this would be the explosion of an atomic bomb.

CHEMISTRY

Vol. 19, No. 9

Formerly The Chemistry Leaflet
Including The Science Leaflet

May 1946

Published monthly by Science Service, Inc., the institution for the popularization of science. Publication Office: 119 South Frazier St., State College, Pa. Entered as second-class matter at the Post Office, State College, Pa., under Act of Congress of March 3, 1879. Address communications to Editorial and Subscription Office: 1719 N St. N.W., Washington 6, D.C.

25c a Copy; \$2.50 a Year. Two-Year Subscription \$4; Your Own and a Gift Subscription \$4. Quantity Subscriptions, 10 or more copies to same address: \$1.70 a Year, \$1 for any seven months, 15c each Copy each Month. No charge for Foreign or Canadian Postage.

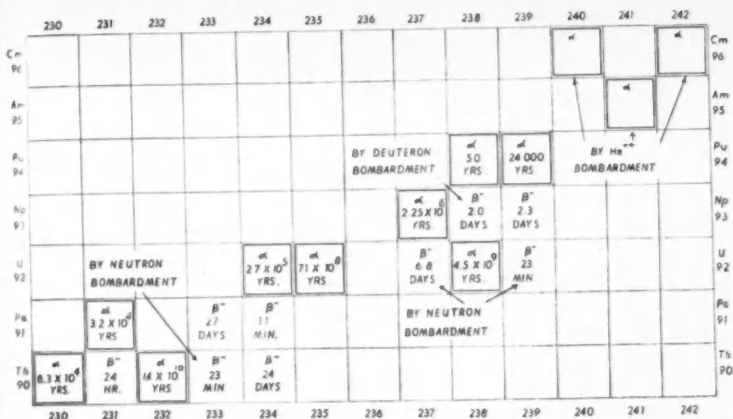
Editors: WATSON DAVIS and HELEN MILES DAVIS

Consulting Editor: PAULINE BEERY MACK (Editor 1927-1944.)

Copyright 1946 by Science Service, Inc. All rights reserved. Science Service issues press service for newspapers and magazines, publishes Science News Letter (weekly), issues THINGS OF Science (monthly) and administers Science Clubs of America.

Science Service is the educational and scientific institution organized in 1921 as a non-profit corporation with trustees nominated by the National Academy of Sciences, the National Research Council, the American Association for the Advancement of Science, the E. W. Scripps Estate and the Journalistic Profession





► THIS CHART, prepared by Dr. Glenn T. Seaborg, shows the isotopes of the seven heaviest elements, including the recently created and newly named Americium and Curium. Stable forms are indicated by an additional outline.

Americium and Curium

► THE TWO NEWEST chemical elements to be discovered, numbers 95 and 96, were christened "americium" and "curium" by their co-discoverer, Dr. Glenn T. Seaborg, of the Metallurgical Laboratory, University of Chicago, in an address before the American Chemical Society meeting at Atlantic City in April.

Made synthetically from uranium and plutonium as a consequence of the atomic bomb research, americium and curium were manufactured in the University of California cyclotron at Berkeley by bombarding U238 and Pu239 with 40,000,000 electron volt helium ions. Dr. Seaborg announced the discovery of these two elements last fall. (See CHEMISTRY, Dec. 1945).

The chemical symbols of the new elements will be Am and Cm.

Element 95 is named after the Americas, or the New World, and element 96 is named after Pierre and Marie Curie, the great leaders in the study of radioactivity.

When neptunium, element 93, and plutonium, element 94, were discovered they were named after the two planets Neptune and Pluto, beyond the planet, Uranus, in the solar system, after which element 92, uranium, was named. But when two more elements were manufactured, there were no more planets of the solar system after which to name them.

So Dr. Seaborg, who was also co-discoverer of plutonium, used in the atomic bomb, let analogy with corresponding elements in the periodic table guide him in naming his new chemical babies.

He found that the new elements are members of a series of elements, which he called the actinide series because its first member is actinium. This corresponds with the series of chemical elements known as the lanthanide earths, which begin with lanthanum. The shells or layers of electrons in the atoms of these elements have similarities. Element 95 has six of what the chemists call 5f electrons and corresponds to the element europium, with six 4f electrons, which was named after Europe. This suggested to Dr. Seaborg naming element 95 after the Americas. Element 96 has seven 5f electrons while gadolinium, with seven 4f electrons, was named after Gadolin, a great investigator of the rare earths. This suggested naming 96 after the Curies.

The preferred pronunciation of americium, according to Dr. Seaborg, is a-mer-ic'i-um, pronouncing the "ic" like "is" in this. The name of this new element is not likely to come into such common usage as many other elements, such as plutonium, one of the fissionable atomic bomb elements, but there may be some tendency in the future to shorten or corrupt it by dropping out the second letter i as has been done in the American usage of aluminum, which in England is still known as aluminium.

Curium is simpler to pronounce, the c being sounded like k.

Co-discoverers of americium and curium with Dr. Seaborg are R. A. James, L. O. Morgan and A. Ghiorso in the Metallurgical Laboratory at the University of Chicago, one of the Manhattan (Atomic Bomb) Engineer District projects. Dr. J. G. Hamilton

and his group at the University of California are credited with vital participation and cooperation throughout. Rebuilding the 60-inch cyclotron to produce the high-energy particles needed, they performed the bombardments.

Dr. Seaborg is professor of chemistry at the University of California on loan to the atomic bomb project and he will shortly return to Berkeley.

In his paper before the American Chemical Society, Dr. Seaborg reviewed the new chemical developments of recent years, leading to the synthesis and subsequent manufacture of transuranium elements, and described the apparatus with which work is done on the fantastically small scale employed in these researches.

I intend to make the transuranium elements the main thesis of my talk, said Dr. Seaborg, that is, the elements with atomic numbers 93, 94, 95 and 96, all of which have been discovered within the last five or six years. The discussion will center around the first isolation and early chemical investigation of these elements and will include a description of the techniques which were developed for this early work, which was done in all cases with amounts weighing a few micrograms or less. This work was all done in conjunction with the plutonium manufacturing process and my statements therefore, so far as atomic energy is concerned, will deal largely with the new synthetic element plutonium, rather than U^{235} , the other material which is of importance to atomic energy. I shall describe much of the early work on plutonium which was pointed toward the development

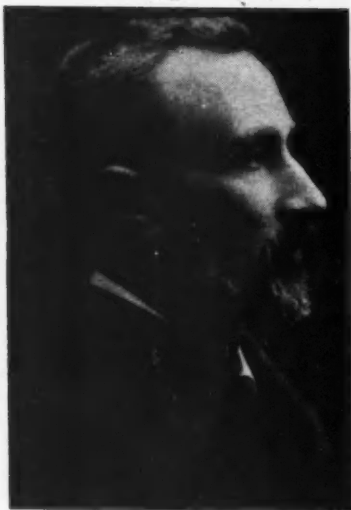


► **AMERICIUM**, element No. 95, was named for the Americas by its discoverer, Seaborg, this year, to correspond to Europium, No. 63, named for Europe by its discoverer, Demarçay, in 1901. Americium's place in the new Rare Earth series corresponds to Europium's in the old.

of methods for its large-scale production and therefore I shall have more to say about plutonium (element 94) than about the other transuranium elements.

The first transuranium element was discovered by E. M. McMillan and P. H. Abelson at the University of California in May, 1940. Using the neutrons from the cyclotron of E. O. Lawrence, they were able to show, on the basis of their chemical and physical experiments, that a beta-particle emitting radioactivity of 2.3 days half-life formed during the irradiation of uranium with neutrons is due to the isotope 93^{235} , which is the decay

product of the 23-minute U^{235} formed by radiative neutron capture in U^{235} . Their experiments on the tracer scale showed that element 93 has at least two oxidation states, an upper state (or states) and a lower state (or states), with chemical properties quite analogous to the VI and IV (or III) forms of uranium. For example, they showed that the 93^{235} under reducing conditions is carried and under oxidizing conditions is not carried from aqueous solution by lanthanum fluoride, indicating that the fluoride of the lower oxidation state of element 93 is insoluble and the fluoride of the higher state is soluble. They found that a



P. Curie

M. Curie

► **PIERRE (1859-1906) AND MARIE CURIE (1867-1934)** at the time they discovered polonium and radium, first disintegrating elements to be recognized. They are honored by the name curium selected for element No. 96 by its discoverer, Glenn T. Seaborg.

greater oxidizing power is required to oxidize element 93 to its upper state than is the case for the corresponding oxidation of uranium. Element 93

later was given the name neptunium by McMillan after Neptune, the planet immediately beyond Uranus, which gives its name to uranium.

Tracer Method

This early work on neptunium was done by the so-called "tracer" technique and it is worth saying a few words in description of this method. The tracer method of investigation of the chemical properties of radioactive elements uses amounts so small as to

be unweighable and the course of the element in the reactions is followed by means of its radioactivity rather than by chemical analysis. Thus, the orders of magnitude of solubilities of the compounds of the radioactive element are inferred on the basis of "car-

rying" experiments, it being generally true that trace amounts are carried well only if the anion of the precipitate forms an "insoluble" compound with the cation being carried. A great deal about the chemical properties of an element can be learned by this method of investigation, which is the only possible method when only sub-microgram amounts are available. However, care must be taken in interpreting the data, and in many cases, completely positive deductions cannot be made. It is important for the purpose of this discussion to understand the difference between this tracer method and the methods of ordinary chemistry wherein the element is studied at ordinary concentrations, so that the element itself may be precipitated in pure form rather than with carrier material.

After the discovery of neptunium, the next transuranium element to be discovered was the element with atomic number 94. This element was discovered by G. T. Seaborg, E. M. McMillan, A. C. Wahl and J. W. Kennedy at the University of California late in 1940. The isotope involved was the one of mass 238 formed by the deuteron bombardment of uranium. These investigators were able to show that the deuteron bombardment of uranium in the cyclotron of E. O. Lawrence leads to a new isotope of neptunium, the 2.0-beta-particle emitter, Np^{238} , formed from a $(d,2n)$ reaction on U^{238} . They found that this isotope of element 93 decays to an alpha-emitting isotope of element 94, namely, 94^{238} , and that this alpha-emitter has a half-life of about 50 years. Their early experiments on the chemistry of element 94 employed



Johan Gadolin

► JOHAN GADOLIN (1760-1852) who discovered yttrium in the black mineral from Ytterby Sweden, in which the first of the rare earths were later identified. Element No. 64 was named gadolinium in his honor in 1886 by the French chemist, Lecoq de Boisbaudran. Gadolinium is similar in electron structure to the new element Curium.

this isotope and were, of course, performed by tracer techniques. These experiments showed that element 94 has at least two oxidation states, an upper state (or states) and a lower state (or states). The experiments indicated that it requires even stronger oxidizing agents to oxidize element

94 to the upper state than is the case for neptunium. Element 94 was given the name plutonium to follow the convention which was used in the naming of neptunium.

The isotope of plutonium which is of major importance is, of course, the isotope of mass 239. This isotope, Pu^{239} , which is the daughter of the 2.3-day Np^{239} , was discovered at the University of California in the spring of 1941 by G. T. Seaborg, E. Segrè, J. W. Kennedy and E. O. Lawrence. It is an alpha-emitter with a half-life of about 24,000 years. Its tremendous importance stems from its property of being fissionable with slow neutrons, a property which places it in a class of importance comparable with that of U^{235} .

Once the value of the isotope Pu^{239} was thus established, the paramount problem was that of producing it on a large scale, and the story of the accomplishment of this is, of course, the story of the Plutonium Project. . .

The question, then, was: How could the separation process be tested at the concentrations of plutonium which would exist several years later in the production plants when, at this time, there was not even a microgram of plutonium available and there was no prospect for having plutonium from a production plant within a year or more? This problem was

solved in a venturesome way, the solution consisting of the following two salient aspects. First, it was decided to produce an actually weighable amount of plutonium by bombarding large amounts of uranium with the neutrons from cyclotrons. It must be remembered that never before had weighable amounts of transmutation products been produced with any particle-acceleration machine. Even extending this possibility to the limit it was not anticipated that more than a few micrograms of plutonium could be produced. The second aspect of the solution of this problem involved the novel idea of attempting to work with only microgram amounts of plutonium but at the same time, at ordinary concentrations. It was decided to undertake a program of investigation involving volumes of solutions and weighings on a scale of operation much below that of ordinary microchemistry.

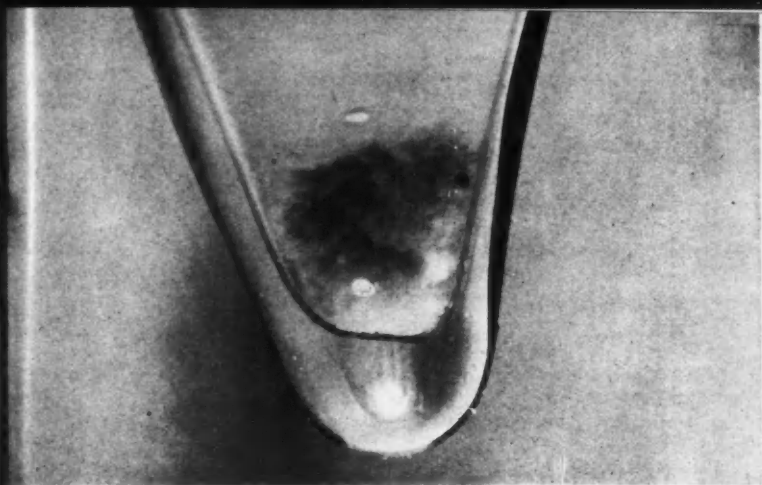
By using extremely small volumes and by weighing microgram amounts of plutonium, it was possible to arrange matters so that even microgram quantities could give us relatively high concentrations. The field which embraces the chemical study of material on this minute scale of operation has been given the name "ultra-microchemistry" by P. L. Kirk, a pioneer investigator in the field of quantitative chemistry on the microgram scale.

Ultra-Microchemistry

I should like to give a brief description of the techniques which are used on this microgram scale or ultramicrochemical scale of operation. The extremely small volumes, of the order of 10^{-3} to 10^{-5} milliliters, are handled

with the help of specially constructed, small capillary containers, pipettes, burettes, micromanipulators, etc. Liquid volumes in the range quoted are measured within an error of less than 1% by means of fine calibrated capil-

solu-
two
ed to
ount
large
neu-
oc re-
had
ation
any
Even
limit
than
could
of the
d the
with
auton-
inary
und-
n in-
and
ation
micro-
umes
ounts
o ar-
gram
high
em-
terial
a has
micro-
oneer
ntita-
scale.
ected,
ettes,
Liq-
l are
than
capil-



► PLUTONIUM HYDROXIDE, a green salt, in the bottom of one of the tiny capillary tubes used for analysis on the ultra-micro-chemical scale. The darker part at the top is a brownish colored compound resulting from a different oxidation state.

lary tubing, the movement of liquid within the capillary being governed by air pressure under sensitive control. The smaller pipettes may be constructed to fill automatically by capillary attraction. The "test tubes" and "beakers" for this work are made out of capillary tubing which has an inside diameter of 0.1 to 1 mm. The weights of solids which are handled in reagents and precipitates are usually in the range of 0.1 to 100 micrograms. For purposes of comparison it is worth mentioning that an ordinary U. S. ten-cent piece weighs about 2.5 grams, 2,500,000 micrograms. This work is usually done upon a mechanical stage of a microscope, with the entire apparatus within the field of view. The test tubes, pipettes, etc., are handled by means of mechanical aids known as micromanipulators. It is

very interesting to note that precision of the order of 0.5% is easily obtainable in work on this scale. The separation of solids from liquids is usually done by means of centrifugation rather than by filtration.

One type of balance which is used in the weighing experiments is the Salvioni balance. This balance consists of a very thin quartz fiber, fastened to a solid base at one end, to which is attached at right angles at the other end a small holder for the sample to be weighed. The measurement of the weight of the sample depends upon the measurement of the amount of bending of the quartz fiber arm, and the balance is usually calibrated by the use of known weights.

Another type of ultramicro-balance used in a number of these investigations has an extremely high sensitivity

and was designed and built by P. L. Kirk and R. D. Craig of the University of California. This balance can weigh amounts as small as a microgram or less with an accuracy of 0.03 micrograms. The material can be in containers weighing as much as 20 mg, i.e., 20,000 micrograms. The beam and other operating parts of this balance are constructed of fibers of pure quartz ranging in diameter from about four times that of a human hair down to fibers which are invisible to the unaided eye. The beam of the balance is a quartz fiber framework some four inches in length which is suspended inside a brass housing on a horizontal fiber at right angles to the plane of the beam. From each end of

the beam there hangs a fiber to which is attached a quartz frame which holds a weighing pan of thin platinum foil. Objects to be weighed are placed on the foil. The addition of a weight to one side of the balance causes the beam to be depressed on that side. The beam is restored to its initial position by twisting in the opposite direction on the fiber which supports it. The amount of twisting necessary to return the beam to its initial position, after the addition of a weight, is measured and used to evaluate the weight added. The movement of the beam is magnified by a suitable optical arrangement, and during a weighing all parts of the balance are protected against the slightest air currents.

First Synthetic Element

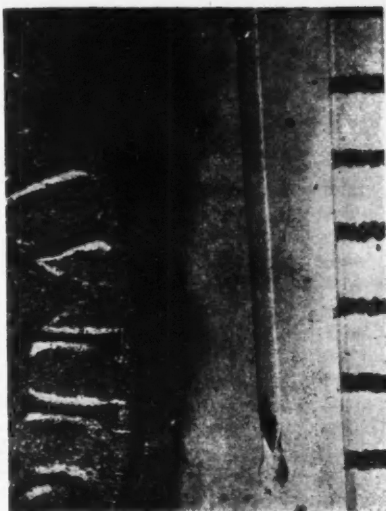
The first pure chemical compound of plutonium, free from carrier material and all other foreign matter, was prepared by B. B. Cunningham and L. B. Werner at the Metallurgical Laboratory in Chicago on August 18, 1942. There was available to these men for the accomplishment of this feat only a couple of micrograms of plutonium produced by the bombardment of uranium by neutrons from the Berkeley cyclotron. This memorable day will go down in scientific history to mark the first sight of a synthetic element, and the first isolation of a weighable amount of an artificially produced isotope of any element.

During the summer of 1942 large amounts of uranium, hundreds of pounds, were bombarded for several months in the cyclotrons of the Uni-

versity of California in Berkeley and Washington University in St. Louis. This resulted in the production of a couple of hundred micrograms of plutonium, happily a great deal more than had been anticipated, and made it possible to extend considerably the program of ultramicrochemical investigation. In September of 1942 Cunningham and Werner were able to prepare a number of compounds of pure plutonium and to determine their formulae with certainty, by means of chemical analysis. The group remaining in Berkeley with Professor W. M. Latimer, including A. C. Wahl, J. W. Hamaker and G. E. Sheline, also contributed to this ultramicrochemical program of investigation and were able to show that the oxidation number of the highest oxidation state is VI. From this time

until the end of 1943 these cyclotron bombardments were the sole source of plutonium, and spread out over this period of time a total of about 1000 micrograms, that is, 1 milligram, of plutonium was prepared. This material was used to maximum advantage by the ultramicrochemists to prepare compounds of plutonium and to measure properties such as solubility, etc. In particular, it was possible, and this was of inestimable importance, to test the separation processes which were under consideration for use at Hanford. The various parts of the complicated separation and isolation procedures were tested in the careful and crucial experiments of Cunningham and Werner and I. Perlman. Without the possibility of these tests, I believe that it is fair to say that the process which is now in use at Hanford and which has turned out exceedingly well would not have been chosen.

I want to emphasize that the scale-up between the ultramicrochemical experiments to the final Hanford plant amounts to a factor of about 10^{10} , surely the greatest scale-up factor ever attempted. In spite of these difficulties the chemical separation process at Hanford, largely the conception of S. G. Thompson, was successful from the beginning and its performance exceeded all expectations. High yields and decontamination factors (separation from fission activity) were achieved in the very beginning and have continued to improve with time. The huge plutonium manufacturing plant at Hanford, Washington, to which I have referred several times during this discussion was built and



➤ NEPTUNIUM appears as a brownish salt in this even tinier capillary tube, beside which the edge of a dime looks as big as a mill-wheel. Millimeter marks are shown on the other edge of the picture.

operated by the E. I. du Pont de Nemours Company, who have done a marvelous job in making this a successful production plant.

In addition to the need for work with pure plutonium in connection with the separations process, it was necessary to determine a number of the physical and chemical properties of the dry salts of plutonium and of plutonium metal. Therefore, the investigation on the ultramicro scale had to encompass this field of investigation also. A number of compounds of plutonium were prepared by reactions involving the solid and gas phases, that is, by dry chemical reactions.

Neptunium Isotopes

Nearly as interesting as the story of the first isolation of pure plutonium is the account of the first isolation of pure neptunium, the second synthetic element to be isolated in pure form. As mentioned above, the early chemistry of neptunium was limited to studies by the tracer technique using the short-lived isotope, Np^{235} . Fortunately, there is another isotope of neptunium, Np^{237} , discovered early in 1942 by A. C. Wahl and G. T. Seaborg at the University of California, which is sufficiently long-lived to make it possible to work with weighable amounts. This isotope is the decay product of the previously known seven-day beta-particle emitter, U^{237} , which is formed as the result of an $(n,2n)$ reaction on U^{238} and is an alpha-emitter of a very long half-life, 2.25×10^6 years.

The first weighable amounts of Np^{237} were produced by the bombardment of large amounts of uranium with the fast neutrons from the cyclotron. The reaction for the production of this isotope is such that the yield is considerably less than that for Pu^{239} , and therefore the total amounts which were available for study were even smaller than the tiny amounts of Pu^{239} referred to above. Nevertheless, L. B. Magnusson, and T. J. La Chapelle at the Metallurgical Laboratory of the University of Chicago were able to isolate the element in the form of pure compounds and to study a number of its important chemical properties. The equipment and techniques, of course, were the same as those described above.

Just as in the case of plutonium, later it was possible to have larger amounts of this isotope. It is very fortunate, indeed, that the large chain reacting units at Clinton and Hanford produce this isotope and that by means of special chemical extraction procedures, it has been possible to extract more than 100 milligrams which has been made available for chemical studies. Using this material, these same men, together with J. C. Hindman, have been able to make an intensive study of the chemical properties of neptunium, leading to the establishment of its oxidation states and the properties of a large number of its compounds. This work has shown that neptunium has the oxidation states VI, V, IV and III with a general shift in stability toward the lower oxidation states as compared to uranium. S. Fried, N. R. Davidson and A. E. Florin are responsible for most of the investigation of the dry chemistry of this element.

The general conclusions from this work are, then, that plutonium and neptunium are similar in chemical properties to uranium with an increase in stability of the lower oxidation states in going toward plutonium.

The experiments of G. T. Seaborg, R. A. James, L. O. Morgan and A. Ghiorso in the Metallurgical Laboratory have recently led to the identification of isotopes of elements 95 and 96, making it possible to study the chemical properties of these isotopes by the tracer technique. These investigators have studied the products produced as a result of the bombard-

ment of U^{238} and Pu^{239} with very high energy (40 Mev) helium ions in the Berkeley cyclotron. This work was made possible by the vital participation and cooperation of J. G. Hamil-

ton and his group at the University of California, who have recently rebuilt the 60-inch cyclotron to produce the high energy particles needed and who performed the bombardments.

New Rare Earth Series

The elements 90 to 94 lie in corresponding positions just below the sixth period transition elements Hf to Os (atomic numbers 72 to 76) in which the 5d electron shell is being filled. The transition elements Hf to Os are similar in their chemical properties to the corresponding 4d transition elements in the fifth period (Zr to Ru, atomic numbers 40 to 44). Although the first members ($_{90}Th$, $_{91}Pa$) of the group 90 to 94 show a great resemblance in chemical properties to the first members ($_{72}Hf$, $_{73}Ta$) in the 5d transition series and to the first members ($_{40}Zr$, $_{41}Nb$) in the 4d transition series, the later members ($_{93}Np$, $_{94}Pu$) show practically no resemblance to $_{75}Re$ and $_{76}Os$ and to 43 and 44 Ru. This suggests that it is the 5f electron shell which is being filled, although it is not possible to deduce from this chemical evidence alone whether uranium is the first element in the series for which this is the case. While it is beyond the scope of this discussion to give all the supporting evidence, we would like to advance the attractive hypothesis that this rare-earth-like series begins with actinium in the same sense that the "lanthanide" series begins with lanthanum. On this basis it might be termed the "actinide" series and the first 5f electron might appear in thorium. Thus the characteristic oxidation state—i.e., the oxidation state exhibited by those mem-

bers containing seven 5f and fourteen 5f electrons—for this transition series is III.

The oxidation state of IV demonstrated by thorium is then analogous to the IV oxidation state of cerium. From the behavior of uranium, neptunium, and plutonium it must be deduced that as many as three of the assumed 5f electrons are readily given up, so that the failure of thorium to demonstrate an oxidation state of III is accounted for. On the basis of this hypothesis, elements 95 and 96 should exhibit very stable III states; in fact, element 96 should exhibit the III state almost exclusively because, with its seven 5f electrons, it should have an electron structure analogous to that of gadolinium, with its seven 4f electrons.

Of course in the case of some of the elements in the series it may be something of an academic matter to assign electrons to the 5f or 6d shells, as the energy necessary for the shift from one shell to the other may be within the range of chemical binding energies. The electron configuration may differ from compound to compound of an element or even with the physical state of a given compound. This shifting of electron configuration would probably be most pronounced with the middle members of the first half of the series—that is, uranium, neptunium, and plutonium.

Since the energy difference between the 5f and 6d shells is rather small and since the resonance effects should

be rather large, the latter may predominate in determining which energy level lies lowest.

Naming 95 and 96

Elements 95 and 96 should of course have names and we propose the following in which these actinide elements are given names by analogy with the corresponding members of the lanthanide earths. We suggest for element 95, with its six 5f electrons, the name "americium", symbol Am; thus this element would be named after the Americas, or New World, by analogy with europium, with its six 4f electrons, which was named after Europe. For element 96, containing seven 5f electrons, we suggest "curium", symbol Cm, after Pierre and Marie Curie, historical leading investigators in the field of radioactivity; this is by analogy with gadolinium, containing seven 4f electrons, which recalls Gadolin, the great investigator of the rare earths.

It is probably worth while to make a brief summary at this point with the following statements. As of today, the periodic system consists of 96 known, identified elements—that is,

there are now positively known at least one isotope, stable or radioactive, for each of the elements from atomic number 1 to atomic number 96, inclusive. The evidence points to an atomic structure for the heaviest elements—that is, those elements with atomic number greater than 88—corresponding to a transition series in which the 5f shell of electrons is being filled. This series differs in chemical properties from the rare earth series (the 14 elements of atomic number 58 to 71, inclusive, following lanthanum) in which the 4f shell of electrons is being filled, in that the first members of this heavy series are much more readily oxidized to oxidation states greater than III. As the atomic numbers of the elements in this series increase, the lower oxidation states, and particularly the III state, increase in stability. The first 5f electron probably appears in thorium, and the stable configuration consisting of seven 5f electrons probably comes with element 96.

Ammonia For Fertilizers

► THREE PLANTS that produced anhydrous ammonia for Army Ordnance use during the war have been turned to civilian production of the critical material, needed for fertilizer manufacture, the War Department has announced.

Army Ordnance plants in Ohio, Kansas and Arkansas will supply 4,000

tons of anhydrous ammonia per month for fertilizer production to help relieve the shortage.

It was also reported that Army Ordnance has sold an excess supply of 35,000 tons of anhydrous ammonia through the Office of Defense Supplies since V-J day.

**Powerful New Instruments
Explore Mysterious Forces**

The Atomic Nucleus

by ISIDOR I. RABI

Dr. Rabi, Professor of Physics and Executive Officer of the Physics Department of Columbia University, Nobel Prize winner in Physics in 1944, describes the forces within the nucleus of the atom. This is another of the talks on nuclear science by masters in the field, broadcast as part of the Philharmonic Symphony—United States Rubber Co. program over the network of the Columbia Broadcasting System. Chemistry reprints it because of the importance to the science of chemistry of the newer knowledge of the nucleus, which this article describes.

➤ IF THE URANIUM atom were enlarged a thousand million times, it would be about a foot in diameter. If its weight were increased proportionately to the increase in volume the atom would weigh about a thousand pounds. In the center of this magnified atom we would find a kernel about the size of a minute grain of sand. This is the nucleus. The part of the atom outside the nucleus consists only of electrons—and in the case of uranium there are 92 of them. These electrons are very light particles, and they move around the nucleus in orbits determined by the electrical forces which control them. On our scale of magnification, the total weight of the 92 electrons would be a quarter of a pound, and all the rest of the thousand-pound mass would be in the tiny

nucleus. In other words, that magnified kernel, about the size of a small grain of sand, would weigh nine hundred and ninety-nine pounds and twelve ounces. A thimbleful of uranium nuclei would weigh thousands of tons.

The nucleus is strikingly different from the electrons not only in mass but also in electrical properties. For, whereas the electrons are negatively charged, the nucleus is positively charged. This is true, not only of uranium, but of all the elements.

For every atom, then, this is the pattern of structure: a central positively-charged nucleus around which a lightweight negatively-charged electron or group of electrons moves at high speeds. In the case of the simplest hydrogen atom there is one revolving electron, and the nucleus carries a single positive charge. As you pass up the scale of atomic complexity, the number of electrical charges increases. Indeed, it is the change in electrical charge that marks the change to a new element. Thus the lightweight gas, helium which is next to hydrogen in atomic simplicity, has two positive charges on its nucleus, and two negatively-charged electrons in motion around this nucleus. Oxygen, to take a common element of the air which is known to all of us, has eight positive charges on its nucleus and, correspondingly, eight electrons whirling

about this nucleus—whereas the inert gas nitrogen has only seven nuclear charges and seven encircling electrons.

We know far more about the electrons than we do about the nucleus, but our assignment today is to examine the nucleus. We shall have to use powerful research tools, for this dense kernel is so very small, and is so masked by the surrounding electrons and by its own strong positive electrical charge, that its secrets are indeed well guarded. Vast energy is locked within the nucleus. The atomic bomb gave evidence of that. In order to penetrate to the nucleus we must apply energies comparable to those already within the nucleus, and this involves instruments of high power. The cyclotron is one such instrument; the uranium pile, another. A very potent device is the recent invention known as a betatron, an apparatus for accelerating electrons to velocities approaching the speed of light. Nature itself has given us one of the most powerful agencies for nuclear studies. I refer to the cosmic rays. These mysterious radiations, which come in from outer space, make available to us energies far beyond those which any man-made device is likely to achieve in the near future.

By the use of research tools such as those just mentioned, physicists have penetrated to the nucleus and have found it an exceedingly complicated structure. This structure is still far from being completely understood, but except for the one case of light-weight hydrogen we know that nuclei are not single indivisible particles but are composite structures. To the best of our knowledge atomic nuclei are made up of two kinds of particles:

Protons and neutrons. The protons each carry a positive electrical charge, and it is they that are responsible for the charge on the nucleus. Thus, in the nucleus of the oxygen atom which, as I said a moment ago carries eight positive charges, there are eight protons; in nitrogen there are seven protons and seven positive charges; and so with each chemical element. The number of nuclear charges is always equal to the number of protons.

The other building block of the nucleus, the neutron, is slightly more massive than the proton and about the same size, but it has no electrical charge whatever and therefore is electrically neutral. Many atoms have in their nuclei equal numbers of neutrons and protons; others have more neutrons than protons. The proportions vary.

We picture the nucleus, therefore, as a very tiny kernel made up of protons and neutrons. Since all protons are charged with positive electricity, they repel one another. Inside the nucleus this mutual repulsion is extremely intense because the protons are so close together. If there were not other forces within the nucleus to counteract this electrical repulsion, the nucleus would instantly explode. But there are present mysterious forces of attraction between proton and neutron, between proton and proton, and between neutron and neutron. These forces of attraction are different from any other kind found in nature. They are not like gravitational or the usual electrical forces. The nuclear forces are not only more powerful, but also they do not seem to take hold until the nuclear particles are practically in contact. Although

physicists have worked for years on the problem of the nature and origin of these adhesive forces, little progress has been made. It was possible to deal with the problem of the atomic bomb, for it involved a few specific nuclear properties which were understood. But to understand the general nuclear forces, we shall need new ideas and principles of which at present we have no hint.

The mass of the proton is 1840 times that of the electron, but its electrical charge is of equal magnitude, though opposite in sign, being positive whereas the electron's charge is negative.

Protons have another and somewhat mysterious property known as spin. That is to say, they rotate. Just as all protons are identical in mass and in positive electrical charge, they all have exactly the same amount of spin. Because of this spin, the motion of a proton within the nucleus has many of the properties of a spinning top, or gyroscope.

The rotation of electricity is always associated with magnetism. So it is with the spinning proton. It is a little magnet with a north and south pole oriented in the direction of the spin. From the general relations which are expected to hold true between mass, spin, and electrical charge, it should be possible to predict the strength of the proton magnet. However, such predictions have failed completely. The measured strength turns out to be almost three times the predicted value. This discrepancy is not understood. It may turn out to be a clue to the nature of the proton and its nuclear forces.

The neutron also rotates, with a spin equal to that of the proton, and the neutron too, is a small magnet. Its north and south poles are arranged in the direction which corresponds to the rotation of negative electricity, even though the neutron is known to be electrically neutral. Any detailed explanation of the magnetism of the neutron is completely lacking.

There is another remarkable behavior of at least some nuclei. It is the property of emitting electrons. One of these nuclei, without any external influence at all, will suddenly shoot out an electron. There is not enough room within the nucleus for an electron to exist there, and its emission seems to be the result of spontaneous generation of the particle within the nucleus. The idea has been suggested that the ejected electron is a by-product of the transformation of one of the nuclear neutrons into a proton. It is indeed true that after emission of the electron the nucleus has one proton more than it had before, and one neutron less. Here again an adequate explanation is lacking. This mysterious transformation of a neutron into a proton with the simultaneous emission of an electron is probably another facet of the many-sided problem of the nature of the nuclear forces and of the structure of proton and neutron.

This afternoon I have tried to stress not so much things that are known, but some of the limitless unknown. Now, as almost never before, there is unbounded opportunity for young men and women to make great discoveries. Newer and more ingenious experiments have to be designed.

Newer and more profound ideas and guiding principles will have to be discovered before the nature of the nucleus is fully comprehended. The great accomplishments of the past have opened still broader and more fundamental fields of investigation, things undreamed of a generation

ago. The more we learn of nature, the more subtle and beautiful her laws become. We can be sure that the next generation of scientists will not fail to take up this challenge and make new discoveries and raise new problems for future generations to solve.



"Well, er, heh-heh, it certainly removed that spot!"

ture, the
er laws
the next
not fail
d make
w prob-
o solve.

New Leads To Better Treatment Of Filariasis and Schistosomiasis

Radioactive Antimony

by JANE STAFFORD

► NEW LEADS to better treatment of filariasis and schistosomiasis, tropical diseases encountered by our troops in the Pacific theatre of the war, and new knowledge of antimony, a chemical with both healing and poisoning properties, are being gained by co-operative research at the National Institute of Health and the Carnegie Institution of Washington.

Results to date of these studies, started during the war and still continuing, were reported by Dr. Frederick J. Brady, of the National Institute of Health, at a meeting of the Washington Philosophical Society.

The studies started with a search for better medicines to treat these two tropical diseases. One of them, filariasis, sometimes develops into the much dreaded elephantiasis.

In this search, 55 chemical compounds were tested. Many of these were new, some were covered by German patents and others had been previously known and used. Of the entire group, four were found more promising as remedies than fuadin, the antimony compound generally used to treat schistosomiasis. However, the scientists found that any trivalent antimony compound was effective in treating these tropical diseases.

The antimony compounds have two effects on the parasitic worms that cause filariasis: 1. They cause the mi-

croscopic worm embryos to disappear from the blood stream; 2. They sterilize the adult female worms which remain in the heart of the infected animal.

This has a bearing on treatment of the disease because hitherto scientists have held that treatment of filariasis in humans would bring on elephantiasis much faster than it would develop without treatment. According to this theory the antimony compound killed the female adult worms and the dead and dying worms in the lymph nodes caused the grotesque and disabling swellings known as elephantiasis. If the adult female worms are sterilized but not killed by the treatment, then the treatment should be effective in checking the disease and preventing elephantiasis.

The action of antimony, though long used in medicine and familiar to the layman in the compound, tartar emetic, has never been fully known. Using antimony 124, a radioactive form of the metal made with the cyclotron at the Carnegie Institution, the scientists have gained new knowledge about this useful but poisonous chemical.

Tartar emetic, made with radioactive antimony, has been given to rats, dogs and men. It leaves the blood stream very rapidly and, in dogs, almost half of it is concentrated in the liver.

The thyroid gland, much to the scientists' surprise, also accumulates a large quantity of the antimony. Relatively small amounts stay in the lymph nodes and skin.

The liver, it was discovered, changes the tartar emetic into a new antimony compound. This, rather than the tartar emetic, may be what is effective in permanently sterilizing adult female worms and killing off the embryonic forms in the blood stream.

Whether this new compound has this remedial effect is not yet definitely known. The scientists do know now that the new compound is soluble in water, is less poisonous than tartar emetic and is excreted from the body faster than tartar emetic. They hope soon to be able to identify the new compound chemically.

One atom bomb research by-product will be to give more information about the action of antimony in the body, Dr. Brady said. Radioactive antimony made by cyclotron bombardment is not powerful enough for study by the tissue autographing technique.

This is a method for exposing photographic plates to radiation from radioactive elements in microscopic sections of body tissues. Examination of the sections shows the very cells of

the body in which the radioactive chemical has been deposited.

When radioactive antimony becomes available from the pile used for uranium fission in atom bomb production, this technique can be used. Scientists will then know which cells of the liver and thyroid, for example, accumulate antimony and from that may learn more of what happens to it in the body or what it does in the body to poison or cure.

More knowledge of antimony and its use for curing schistosomiasis and filariasis is also expected from studies like those that developed BAL, the British anti-lewisite chemical that became a remedy for arsenic and mercury poisoning. BAL itself may be used in this phase of the work which will involve study of body enzymes. Arsenic poisons by tying up sulfhydryl groups in enzymes and BAL saves the victim by overcoming this chemical linkage. Antimony may similarly act through body enzymes.

A remedy for antimony poisoning, similar to BAL for arsenic poisoning, could then be developed, or BAL itself might prove useful. The importance of this lies in the fact that doctors must give antimony in poisoning doses to treat schistosomiasis effectively.

Sweetness For Mold

► LACTOSE, or milk sugar, is used in giving the penicillin-producing mold a well-balanced diet. Although the mold grows luxuriantly on almost any nutrient solution, it will not make penicillin unless conditions in its diet

and environment are carefully controlled. Thus corn steep liquor, lactose and some essential salts and water are used in producing the germ-killing mold.

For The Home Lab

Isolation of Boron

by BURTON L. HAWK

► EVERYONE is familiar with borax as a cleansing agent and the properties of boric acid as an eyewash are well known. We all have, no doubt, at some time washed our hands with borax and our eyes with boric acid. But despite the popularity of these compounds of boron, the element itself is a rarity.

Boron has very few uses in the elemental state and is extremely difficult to prepare with any degree of purity. Consequently, its production is limited and its price is high. But we feel that it makes an interesting collector's item for the shelves of the home lab and its isolation presents a challenge to the home chemist.

It was in 1808—when Beethoven was composing his greatest music and Napoleon was rising to his greatest power—that boron first appeared as a new element. Its isolation was accomplished by Thenard and Gay-Lussac in France and Davy in England. They decomposed boric acid by heating it with potassium (*see CHEMISTRY Feb. '46 - p. 54*).

This procedure is both dangerous and costly and boron is usually prepared now by reducing the oxide with magnesium: $B_2O_3 + 3Mg \rightarrow 3MgO + 2B$. This method can most easily be employed in the home laboratory.

First it is necessary to prepare the boron trioxide. Place about 5 grams of boric acid in an evaporating dish

and heat thoroughly for five minutes in order to drive off the water. Actually, three reactions occur during this heating. The acid first loses a molecule of water to form metaboric acid: $H_3BO_3 \rightarrow HBO_2 + H_2O$. Upon further heating the tetraboric acid (parent acid of borax) is formed: $4HBO_2 \rightarrow H_2B_4O_7 + H_2O$. And finally, the oxide: $H_2B_4O_7 \rightarrow 2B_2O_3 + H_2O$. We are, of course, concerned with the oxide, which is a brittle, semi-transparent, glass-like solid.

Break off a few chunks, and grind in a mortar to as much of a powder as possible. Now take about $\frac{1}{2}$ to 1 gram of oxide and mix it thoroughly with an equal amount—by weight—of magnesium powder. Place the mixture in a crucible, cover it, and heat to redness. It is advisable to continue heating at this temperature for at least fifteen minutes. Then allow the crucible to cool thoroughly; remove the cover, and examine the contents.

The grayish-black mass contains free boron, magnesium oxide, magnesium and a little magnesium boride. Boron is insoluble in hydrochloric acid; therefore it is possible to dissolve the other products in the acid, leaving the boron as a residue. Scrape the contents from the crucible into a beaker and add dilute hydrochloric acid. Keep adding acid and water from time to time until you are pretty sure that all soluble substances have dissolved. Then filter and dry

the residue; wash with water and dry again. The product is impure boron. It usually is obtained as an amorphous brown powder.

Boron can also be obtained in the crystalline state as grayish-black, hard, lustrous crystals. It is possible to crystallize boron from molten aluminum, although the product contains aluminum boride. You can attempt this crystallization by melting a few pieces of aluminum in a crucible. Sprinkle the amorphous boron in the molten liquid and pour the contents into a large container of water. The aluminum is then dissolved in hydrochloric acid, leaving the boron behind.

It is also possible to obtain boron by heating borax with red phosphorus, the reaction depending upon the strong affinity of phosphorus to oxygen. In all cases the boron is impure. Recently, boron has been obtained in

a high state of purity by electrolysis of boron chloride using high-potential alternating current arcs.

Now that you have obtained boron (we hope), the question arises, what can you do with it? Well, the answer is: nothing. As stated previously, boron has very few uses, and pure boron costs about \$5.00 per gram. It has been used to some extent in thermometers and thermo-regulators. Because of its extreme hardness, the crystalline form is used in place of the diamond in industry.

So—put your boron in a vial—label it Boron, symbol B, atomic weight 10.82. And take pride in the fact that you have a supply of a “rare” element! And be proud of the fact that you have accomplished the difficult isolation of it in your own laboratory! And rejoice in the fact that you have saved yourself \$5.00!

What Chemists Call Synergy

► “Two PLUS TWO makes five,” or “The whole is greater than the sum of its parts,” expresses the basic idea of the term synergy as used in chemistry, stated Dr. Pat Macaluso of Foster D. Snell, Inc., at the meeting of the American Chemical Society. As an example he referred to pyrethrum, a common active agent poisonous to flies, whose effectiveness is tripled when mixed in the spray with a small amount of sesame oil, which in itself is harmless to household flies.

Dr. Macaluso presented a generalization of the nature of synergy and the factors underlying it, which, he

said, have now been made for the first time in the field of industrial chemistry, but do not represent any new discovery of principle.

Synergy in chemistry is the co-operative action of two distinct substances “such that the total effect is greater than the sum of the two effects taken separately,” he explained. “It is a commonplace of chemistry,” he continued, “that a greenish yellow poison gas like chlorine and a bright silvery inflammable metal like sodium will react to give common table salt or sodium chloride, which is neither sodium metal nor chlorine gas, nor their sum or average.”

Highlights From A.A.A.S. Meeting

by DR. FRANK THONE

► HOW PLANTS utilize light, what compounds they form with its aid, how insects can better be combatted and how some animal instincts work, are among the researches on which progress was reported at the recent meeting of the American Association for the Advancement of Science in St. Louis, the first large scientific get-together since the ending of wartime travel restrictions. News in some biological fields very close to chemistry comes from papers delivered at the meeting.

"Heavy" Carbon as Tracer

► WHEN A PLANT takes in carbon dioxide molecules from the air, and cracks off the carbon atom to use in making food and other substances, it is an efficient and a rapid chemical worker. Use of a "tracer" element to find out how fast plants work was reported before the meeting by Dr. G. S. Rabideau and Dr. G. O. Burr of the University of Minnesota.

They used the "heavy" carbon, of atomic weight 13, that occurs in nature and can be separated out by physical methods. Because of its greater weight, it can subsequently be identified in compounds which it enters. This makes it useful as a tracer element.

Carbon dioxide made by burning carbon 13 was supplied to the leaves of radishes and beans, in the experi-

ments reported by the two Minnesota plant physiologists. At intervals after this gaseous feeding, parts of the plants were analyzed to see where the tracer carbon atoms had gone. It was found that within a very few hours there were carbon 13 atoms not only in the carbohydrate and protein foods formed by the plants, but in the permanent cellulose supporting tissues as well.

Fluorescence in Plant Analyses

► FLUORESCENCE, the ability of some substances to shine with a visible light of their own under ultraviolet or visible radiations, was used as a delicate method of plant-substance analysis, in experiments reported by Prof. Richard H. Goodwin of Connecticut College.

Chlorophyll, the green pigment in plants, is really a double pigment; its fractions are commonly called chlorophyll A and B respectively. Prof. Goodwin found that A shines 11 times as much as B under violet light, and about three times as much under blue light. Since there is always a great deal more of A than there is of B, a measurement of the brilliance of fluorescence of a chlorophyll solution can be used to give a very close estimate of its concentration.

Dr. C. Guinn Barr of the Michigan Agricultural Experiment Station reported on the use of fluorescence to detect the presence of two important

plant acids, succinic and malic, and to measure their concentration.

Chlorophyll in Camouflage Paint

► BECAUSE THE BEST military concealment has been obtained by hiding behind a screen of green leaves, ever since Birnam Wood came to Dunsinane Hill, camouflage artists have long desired to use the green stuff in the leaves, chlorophyll, in camouflage paint. Such attempts have not been too successful, because chlorophyll breaks down and fades out too rapidly, once it is deprived of the support of the living leaf.

Prof. C. S. French and Dr. R. E. Brown of the University of Minnesota told of their efforts to prepare a chlorophyll paint made from ground leaves and other ingredients, during the recent war. They found the most effective stabilizers to be glucose and other sugars, methyl cellulose, sorbitol and a commercial mildew preventive. Greatest stabilization was obtained with sorbitol borate, which reduced the rate of bleaching 25 times. It was not possible to make a successful oil paint containing chlorophyll. A good water paint, however, was evolved. Cards painted with this, then varnished, were still unfaded after three weeks' exposure to full sunlight.

DDT-Like Compounds Deadly

► DDT, ONLY NOW coming into general public use as a defense against insects, may presently be rivalled or outmoded by close chemical relatives that are even more deadly, it was suggested in a report of researches presented by Dr. Eugene P. Odum and Prof. W. T. Sumerford of the University of Georgia.

What the two zoologists were hunting for was a chemical like DDT that would be less deadly to fish, and still able to kill insects. Fisheries men, and conservationists generally, are much concerned about ill effects of DDT sprays and dusts distributed over inland waters to kill mosquitoes.

Dr. Odum and Prof. Sumerford used compounds resembling DDT, except that the chlorine atoms in the DDT molecule were replaced with the related elements iodine and fluorine. The fluorine-containing compound was even more poisonous to fish than DDT when used in the same concentration. However, its deadliness to insects was increased to an even greater extent, so that there may be some hope of finding a concentration that will wipe out the mosquitoes and their "wigglers," and yet not prove fatal to the fish.

Quinine and Malaria Germs

► WHILE ENTOMOLOGISTS and zoologists are out with DDT and other killing stuffs to knock out mosquitoes, medical scientists are making a more direct attack on the germs they carry. Dr. E. A. Evans, Jr., of the University of Chicago told of his studies on the biochemistry of malaria germs, in an endeavor to find a weak spot where they can be attacked more successfully. One of the things he discovered was that drugs like quinine and atabrine appear to decrease the parasite's ability to use sugar as food. These findings, though still incomplete, indicate the possibility that future work along similar lines may provide knowledge leading to the synthesis of more effective antimalarial drugs.

Light Rules Flower Formation

► THE FACT that many plants are stimulated to produce flowers and fruit by the increasing length of daylight hours, and that other plants are kept from flowering by the same treatment, has been known for a quarter-century or so. Newest refinement in studies along this line was presented by a group of four U. S. Department of Agriculture scientists, who have shown that the stimulating effect is greatest at certain wavelengths, and that even a few seconds of light of the right color will suffice to initiate or suppress blossoming.

They set up a powerful arc lamp in their laboratory at Beltsville, Md., and split its light with a prism, to produce a rainbow band of color against a screen 40 feet away. They set their experimental plants in a row along this spectrum, so that each would get light of just one color, or a very narrow wavelength band, on one leaf. Most effective in controlling flowering, they found, were wavelength bands in the orange-red and violet regions of the spectrum.

The research team was composed of Dr. M. W. Parker, Dr. S. B. Hendricks, Dr. H. A. Borthwick and Dr. N. J. Scully.

Young Turtles Seek Light

► IT IS NOT a mysterious inherited memory of their ancestors, but a simple natural tendency to turn toward the light that makes newly hatched loggerhead turtles find their way unerringly from their deep nest in the sand to the ocean, Dr. Robert

S. Daniel, of the University of Missouri, and Dr. Karl U. Smith, of the University of Wisconsin, reported to the meeting.

The turtles, they found, go toward the white surf, which is the brightest area under all lighting conditions on the beach.

When turtles were released on the beach on a dark night, they did not succeed in reaching the water, and their tracks showed only aimless wandering. With a bright moon over the water and a flashlight pointed at them from the land side, 25 out of 50 turtles moved toward the flashlight and the others toward the moon and the sea. They go toward the light that is brighter to them, making a choice when the ratio between light intensities is as close as 1 to 1.1. If one eye is covered, the turtles merely travel in circles.

Poorer Food From Poor Soils

► SOILS THAT ARE old and partly worn out are ill-fitted chemically to produce plant foods good for growth and reproduction purposes, Prof. William A. Albrecht of the University of Missouri declared. The forces of the weather take calcium out of soil more rapidly than they do potassium. This leaves the soil better able to produce fattening foods with high carbon content but less able to grow crops with the high nitrogen and mineral contents needed for really healthy animal life.

Prof. Albrecht spoke as retiring vice-president of the American Association's section on agriculture.

Cider vinegar, in some states, must contain a minimum of 4% by volume of acetic acid.

**American Rocket Pioneer
Awarded Patents Posthumously**

Rocket Patents and Other Inventions

Chemists will be interested in the new patents reported here. If you want a copy of any patent remit 10 cents (not in stamps) and order by number from the Commissioner of Patents, Washington 25, D.C.

► INVENTIONS of potential military importance, which for obvious reasons had to be kept under wraps during the war, are now beginning to be disclosed through the issuance of U. S. patents. One such is a long-range rocket, on which patents 2,395,113 and 2,395,114 have recently been granted to the late Dr. Robert H. Goddard, of Clark University and Roswell, N. M.

The first patent is on the fuel system, which calls for the use of gasoline and liquid oxygen. Immersed in the oxygen tank is a smaller tank containing liquid nitrogen. This is first piped through a coil around the combustion chamber as a coolant; this returns it to gaseous condition, and it is then used to maintain pressure equilibrium in the gasoline tank as fuel is withdrawn.

The second patent is specifically on the combustion chamber, which is mounted in ball bearings, and has slanting ribs or vanes inside the nozzle, so that it spins like a top as the fuel burns. This rapid rotation effects more rapid and efficient combustion.

There is also a design for what might be called a rocket landing-

strip to receive, if not space-ships from Mars and Jupiter, at least the ultra-high-speed stratosphere craft which rocket propulsion may make possible.

U. S. patents 2,395,403 to 2,395,406, inclusive, have been granted on applications of the late Prof. Goddard covering various phases of rocket construction and use.

The rocket-ship landing device is really a big tube closed at one end, and with a trumpet-like flare at its open end. The rocket-craft is expected to enter this like a ferry going into its slip; wheels at various points on its circumference help to guide it smoothly. As it passes into the narrower part of the tube it will practically fill it, and will thus act as the piston in a grand-scale pneumatic shock absorber. As its nose reaches the closed end it will contact a final checking device built on the principle of the recoil cylinder under an artillery piece.

One of the remaining three Goddard patents is on a combination propulsion unit that functions chiefly as a rocket, but also acts as a gas turbine to drive an air propeller. The other two patents cover new designs for combustion chambers. In one, a series of plates set at angles guide the incoming sprays of fuel and liquid air in such a way that combustion takes place in the center of the chamber, with a layer of cooler gas near the walls. The other chamber rotates,

with the fuel and liquid oxygen supplies so arranged that the centrifugal effect of the whirling makes the fuel feed more efficient.

For still higher reaches of the atmosphere—and space—three more patents have been added to those recently granted on applications of the late Prof. Goddard. They are numbered 2,396,566 to 2,396,568, inclusive.

The first is for an exploratory research rocket, to be propelled by a series of explosive charges, automatically fed from a tubular magazine and set off in series. The second covers automatic steering apparatus for aircraft, hydropneumatically controlled. The third is on a triple-walled combustion chamber for the gasification and burning of gasoline and liquid oxygen, the feed being arranged to keep the thin metal walls below melting heat.

Another patent, no. 2,395,809, is on a mechanism for controlling the rear steering vanes of long-range rockets, so that they will engage the propellant blast sufficiently to keep it on course.

Of three more patents, 2,397,657 to 2,397,659, issued on applications of this American pioneer in modern rocket science, two are on means for automatic control during flight, the third is on a triple-walled combustion chamber in which the inner wall is cooled by fine sprays of liquid oxygen to keep it from melting.

Two more of his rocket patents, numbers 2,397,998 and 2,397,999, describe improvements on earlier inventions by the rocket pioneer and include a more simplified system for

shifting from propeller to rocket operation and vice-versa.

One-half of the patent rights are assigned to the Guggenheim Foundation, which contributed heavily to the support of Dr. Goddard's researches.

Chromium Plating Gun Bores

➤ **ALTHOUGH** the war is over, at least a trickle of military inventions continue to flow through the Patent Office. Two such are of more than passing interest.

The first is covered by patent 2,395,044, issued to an ordnance officer, Col. Walter T. Gorton of Springfield, Mass. Col. Gorton has discovered that electroplating the bores of artillery pieces with chromium or other corrosion-resistant metal greatly reduces the erosive effects of the high-pressure powder gases, and so lengthens the useful life of the guns. Rights in the patent are assigned royalty-free to the government.

The other patent is No. 2,395,353, on a new high explosive consisting of one part of nitroglycerin milled into four parts of TNT; a little jellied guncotton may also be added. This mixture is said to be surprisingly insensitive to shock, yet to possess high brisance, or suddenness of burst, when detonated. The inventors, James Taylor and Samuel H. Davidson of Saltcoats, Scotland, have assigned their rights to Imperial Chemical Industries, Ltd.

Wooly Glass

➤ **THE SILKINESS** of spun-glass fibers is converted to crimped woolliness, for better felting into filter mats and the like, by running them over a corrugated drum under the pressure of a

blast of hot air to keep them soft, in the process on which S. M. Dockerty of Pawtucket, R. I., has obtained patent 2,395,371. Rights are assigned to Owens-Corning Fiberglas Corporation.

De-Gassing Molten Metals

➤ GETTING UNDESIRABLE GASES out of molten metals is the problem attacked by the process on which Arthur T. Cape of Columbus, Ohio, was awarded patent 2,395,458. It was already known that this could be accomplished by getting the metal into intimate contact with carbon dioxide, but previous attempts to accomplish this have not been very successful. Mr. Cape turns the trick by using, not gaseous carbon dioxide, but the solidified form known commonly as "dry-ice." This is submerged in the molten metal by various means; it of course vaporizes rapidly and in bubbling through the hot liquid carries off the contaminating gases.

Oil Digested Out of Fish Livers

➤ A SIMPLE, low-cost method for getting vitamin-rich oil out of cod, shark and other fish livers is the subject of patent 2,395,790, obtained by Ivan A. Parfentjev of Nanuet, N. Y. Instead of the elaborate and costly machinery for extracting the oil from the liver tissues by pressure and heating, Mr. Parfentjev literally digests it out. He puts the livers through an ordinary grinding machine, then acidifies lightly, adds a little pepsin, and lets the material stand until this enzyme has broken down the confining cell walls by the same kind of process that occurs in a man's stomach after he has eaten meat. In a few days the yellow oil rises to the surface and can

be removed. The inventor points out that this method can be used to extract fish oils in the tropics and in other remote parts of the world, where transportation costs at present prevent the taking and shipping of whole fish livers.

Stronger Vinegar

➤ A NEAT IDEA for obtaining stronger vinegar is covered by patent 2,395,510, taken out by F. C. Silbernagel of Manitowoc, Wis. He ferments dilute alcohol into vinegar in the usual way, adds lime to take up the acetic acid, forming calcium acetate. With the acetic acid removed, the fermenting bacteria are free to work on new additions of alcohol to make more acetic acid. Finally, just enough sulfuric acid is added to release the acetic acid again, and to remove the lime as insoluble calcium sulfate.

Vitamin D Material

➤ ERGOSTEROL, which after ultraviolet irradiation becomes vitamin D, can be quantity-produced at low cost from mass-cultured yeast by a new process on which patent 2,395,115 was granted to Kenneth J. Goering of Ames, Iowa, assignor to Anheuser-Busch, Inc. The yeast is first cooked with a weak alkaline solution until all the fats have been saponified and dissolved out. Then the residue, still containing all the sterols, is treated with alcohol, which dissolves the sterols. Subsequently the alcohol is evaporated off, leaving the sterols in crystalline form.

Mixture to "Freeze" Door

➤ AIRPLANES of the probably near future, that will cruise the thin, cold air of the stratosphere, will need something to make a tight seal around doors and other necessary openings,

so that the precious pressurized, warmed air in their cabins will not leak out. The idea of Warren A. Custer of Newton, Pa., is literally to freeze such cracks shut with a substance that is liquid at ordinary ground-level cold temperatures but that freezes at the 67 degrees below zero Fahrenheit encountered at high-level cruising altitudes. On this he has just been granted U. S. patent 2,395,852.

While the patent covers any substance that will accomplish this end, the one which Mr. Custer concretely proposes is based on a mixture of dibutyl phthalate and wet nitro-cotton, to which other ingredients may be added if desired. An oily liquid at ordinary temperatures, it solidifies in subzero cold, clinging tightly to the solid surfaces to which it has been applied. When it is frozen it behaves like thick grease or wax, with a certain amount of "give," instead of being rigid and brittle like ice.

Air Purifier for Submarines

► AN INVENTION to increase safety for voyagers at the opposite pole of travel, i.e., in submarines, is offered by J. D. Morgan of South Orange, N. J., and P. B. Levitt of Millburn, N. J., for patent 2,396,190. To eliminate the explosive hydrogen gas evolved by storage batteries, it passes the air over the batteries through a heated cylinder containing porous porcelain marbles impregnated with platinum black, a well-known hydrogen absorbent. Rights in this patent have been assigned to Cities Service Oil Corporation.

Spraying Device

► A COMPACT insecticide-spraying unit that can be hung under the wing

of a plane is protected by patent 2,395,827, granted to C. N. Husman and O. M. Longcoy of Orlando, Fla. It comprises a tank for the solution, a set of spray nozzles, and a pressure pump driven by a propeller getting its power from the plane's slipstream. Patent rights are assigned royalty-free to the government.

Insecticides

► ALSO GOVERNMENT-DEDICATED are patents 2,396,012 and 2,396,013, both obtained by H. A. Jones and B. V. Travis, both of Orlando. These patents cover two new insect-repelling compositions useful against mosquitoes. The first is based on a phenol compound, 2-phenylcyclohexanol; the second on another organic substance, 2-ethyl-n-caproic acid.

Grease from Bones

► IN THESE DAYS of acute fat shortage, interest attaches to a process for getting the last bit of soap-making grease out of animal bones, invented by Camillo Mueller of New York, and covered by patent 2,395,900. The ground-up, wet bone material is heated in a closed container, then subjected to vacuum, which sucks the grease out of the inner cavities.

Weed Killers

► AN ADDITIONAL GROUP of weed-killing chemicals is covered by patent 2,396,513, granted to Franklin D. Jones of Upper Darby, Pa. The group includes phenoxy-acetic acid and a number of related compounds. Mr. Jones is holder of the patent on 2-4-D, already widely publicized as a weed-killer.

Atomic Energy Plant Operation

► **ENGINEERS** faced with new problems in the utilization of heat from atomic power plants will at least have as a starting point the familiar conditions of heat exchange, it appears from a paper given recently at Chattanooga before the American Association of Mechanical Engineers, by Prof. W. G. Pollard of the department of physics of the University of Tennessee.

Thousands of millions of degrees Fahrenheit temperature are reached by the individual atoms of fission products in an operating atomic pile. But after these have been brought into equilibrium with the coolant, the resulting fluid, heated in the process, can be handled in boilers designed for steam or mercury vapor in processes already familiar.

The problem of bringing the intensely hot particles into equilibrium with the coolant is not unlike mixing one's bath water. The user of atomic energy can, within practical limits, choose the temperature of the resulting mixture, for the fission fragments are at so high a temperature that any man-made temperature will still be cool by comparison.

This intense heating results from collision of atomic particles. The fission fragments are stopped, for the most part, in the metal rod where they are produced. This results in an intense heating of the rod, so that arrangements must be made for effi-

cient heat transfer from the rods to the coolant, which is air, water or molten bismuth flowing through the pile where fission is carried on.

It is possible, says Prof. Pollard, to heat the coolant to any desired temperature because the fission fragments are liberated in the metal at a temperature of many million degrees Fahrenheit. The hot coolant will be radioactive on leaving the pile but it can be passed through a boiler or heat exchanger to produce steam or mercury vapor at high pressure and then returned to the pile.

Radioactivity

Another important aspect of pile design and operation involves protection against radioactivity. Throughout the body of the rods of fissionable material in a going pile small amounts of elements like barium, krypton, iodine, yttrium, etc., are being generated. After coming to thermal equilibrium and collecting some electrons to complete their transmutations, these new elements undergo a whole series of radioactive disintegrations, like radium, before reaching stable forms. Gamma rays given off in this process must be absorbed by the thick screens which must always surround the pile, and this absorption again creates heat and the necessity for cooling.

The fast fission neutrons are produced at a steady rate in the metal at

a temperature of some 10,000,000,000 degrees Fahrenheit. They represent a very dilute but very hot gas which diffuses out into the moderator where it is cooled down by mixing to the temperature of the moderator. As a cool gas it diffuses back into the metal where it can produce more fissions. This represents a true convective heat transfer. The problems of nuclear reactions, the energies involved and the problems of handling radiations are well known in physics but have not been generally included in engineering training.

Fission Products

In addition to atomic energy as a source of power, comparable to any other fuel, the unique products of fission reactions will be a reason for operation of such installations, according to Prof. Pollard. Plants for the production of various isotopes will be required.

The isotope is as important in a nuclear reaction, says the Tennessee physicist, as the molecule is in a chemical reaction. A variety of special isotopes will be required for future technical developments and these will require special plants for their production.

Such plants require unit operations unfamiliar to present engineering practice. They may be based on thermal diffusion columns, gas diffusion through barriers, mass selection of ions in a magnetic field, ultracentrifuges, or special chemical exchange reactions. The engineering of such plants may be expected to be an important new field for oncoming engineers.

Two Nuclear Reactions

In regard to the future of atomic energy, Dr. Pollard discussed two sorts of nuclear reactions. In the first sort both reacting nuclei contain one or more protons. In the second neutrons take part. The first kind of reaction would take place if we could bring together atoms of some of the light elements closely enough to allow their nuclear forces to act.

Hydrogen would react with lithium, under these circumstances, and give out energy of the order of 30 million kilowatt hours per pound of lithium burned, or nitrogen could be reacted with heavy hydrogen to release eleven and a half million kilowatt hours per pound of nitrogen. Neglecting considerations of thermal efficiency, any of these reactions could be used to operate a 50,000 kilowatt power plant on a continuous basis with a fuel consumption of about a pound per week.

"Not only is this perfectly possible," said Dr. Pollard, "but a vast number of power plants of this type are at present in continuous operation throughout the universe. These are the familiar stars, including our own sun."

Enormous central temperatures and enormous pressures in the stars hold together these light nuclei so that the reactions which we observe can take place. In the other sort of reaction, resulting from action of neutrons, which has been made to work here on earth for production of the atomic bomb, the difficulty is that neutrons do not exist as such in nature.

With the exception of a negligible number in cosmic rays they are all to

be found captured in atomic nuclei from which they can be removed only with the expenditure of considerable energy. Thus we are faced with a difficult dilemma. Materials for the first class of reactions are abundant but the conditions to make them go are prohibitive. For the second class the conditions of operation are ideal for a practical atomic power plant, but the essential material for them is non-existent as a natural substance.

The one reaction capable of maintaining a sustained source of neutrons is the fission reaction. In a light nucleus the repulsion between the protons due to their electric charge, although very strong by molecular standards, is yet only a negligible part

of the intense nuclear forces binding the particles together.

In a heavy nucleus near the top of the periodic table there are, however, so many protons that their repulsion becomes comparable to the nuclear cohesive force. As a result a relatively small disturbance of the nucleus can upset the equilibrium so that the nucleus divides into two pieces which are quickly pushed beyond the range of the nuclear forces.

Under the great force of repulsion between the large positive charge on each, the two fragments then fly apart with enormous kinetic energies. The heat generated in slowing down and stopping them is the major source of energy in a uranium power plant.

How Red-Headed is a Red-Head?

► JUST HOW red-headed a red-head is can now be told with scientific accuracy, thanks to a discovery by two University of Chicago scientists. Dr. Peter Flesch and Dr. Stephen Rothman.

They have found in human red hair an iron-containing pigment never known before. The redness of human hair, if it is not dyed, is proportional to the amount of this pigment in the hair, the scientists report in the *Journal of Investigative Dermatology*.

None of the pigment has been found in red hair from animals.

The new pigment does not of itself account for the color of human red hair, for removal does not change the color of the hair. Probably it modifies in some way the usual process of pigment production so that

instead of the black melanin, which gives the color to black and brown hair, a red derivative of melanin is produced.

The pigment appears to be deposited in the central part of the hair as tiny granules which are normally invisible even under the microscope, but which can be demonstrated by a technique described by the authors.

The chemical structure of the new pigment is not known, but the authors' studies indicate that the empirical formula is probably $(C_{15}H_{20}N_2O_9)_2Fe$. They have perfected a simple method of extracting it.

The discovery of this pigment may have value in human heredity studies on the question of inheritance of red hair.

Chem Quiz

Where Do Elements Get Their Names?

► CHEMISTRY has from time to time printed Quizzes about the elements named for their colors, the homes of their discoverers and the mythological characters who are in evidence in the list. This month the Quiz rounds up a miscellaneous lot. Can you recognize them? Their symbols are on page 36.

1. The names of several elements come from traditional names of substances in which they occur. Can you spot the element from (a) an astringent medicine, (b) a jewel in Aaron's breastplate, (c) a soldering flux, (d) flint, (e) a heel.

2. Three elements were named for people, (a) a Swede, (b) a Russian, (c) a Frenchman and a Pole.

3. Two elements were named for America.

4. Four elements have names with rather fanciful associations:

(a) This element seems to have reminded its discoverer of a deaf-mute.

(b) This element's English name might make you think of Cinderella.

(c) This element's name, through an Arabic-Greek pun, came to mean *male*—a regular he-man element.

(d) This element might say, "I'm a stranger here myself."

5. Several elements have heavenly associations: (a) Earth, sun and moon; (b) four planets; (c) two asteroids; (d) the morning star.

6. Here are ten elements actually named for their properties! (a) Four have names derived from the rays they emit; (b) two have names meaning heavy; (c) two mean hidden; (d) two mean stinky.

Diamond Wheel Saves Time Cutting Plastic

► A DIAMOND-IMPREGNATED cutting wheel, developed at the National Bureau of Standards, simplifies and shortens the time required to cut plastic test specimens for tensile and tensile-shear determinations. It can be used satisfactorily with thermosetting plastics, thermoplastics containing a high proportion of glass or mineral filler, and unplasticized rigid thermoplastics such as styrene and methyl methacrylate resins.

The new method will prove of much value to industrial and other laboratories. Using special procedures developed at the Bureau, a good quality of cuts is obtained, and the method is rapid and inexpensive. Moreover, the wheel will not cut soft materials or the hand of the operator. It is made of a metal that permits pressure to be applied to the side of the wheel without danger of fracture. There is very little hazard in its use.

**Emphasis on Science Scholarships
Urged by President Conant**

Aid for Young Scientists

► **OPINION** in favor of federal aid to scientific research and education was generally expressed by members of the American Association for the Advancement of Science at St. Louis for their first postwar national meeting. This feeling was commented on by the president of the Association, who is also president of Harvard University, Dr. J. B. Conant.

While scientists generally, and a large segment of public opinion as well, support the idea of aid to science for the national welfare and safety, there has been so much emphasis on research that the establishment of scholarships for promising young scientists is in danger of being disregarded, Dr. Conant said. More emphasis, he feels, should be placed on this aspect of government-supported science.

The speaker discounted two general criticisms that have been advanced against the program by some persons. First of these is the belief that the placing of so much stress on science will give it an unfair competitive position in relation to other branches of learning. Dr. Conant expressed doubt that students whose natural bent was to literature, fine arts or the social sciences would be tempted away from their careers by scholarship aid in subjects that do not attract them. Moreover, he suggested, it may very well prove desirable eventually to

extend the federal-aid program to non-scientific branches.

The second objection is the one most frequently heard: that federal aid to science would further weaken state and local governments. Dr. Conant declared himself "strongly for states rights" and decentralization generally. He favors putting the administration of federal science scholarship funds into the hands of states and local communities, "without strings, as far as possible."

In any case, he continued, the number of students taking advanced training in such highly specialized subjects as physics, chemistry and engineering is relatively small; and when they get to work in their professions they are really national assets anyhow, since their activities transcend state lines.

Dr. Conant defended the proposed selection of candidates for federal science scholarships by state quotas, rather than choosing the likeliest young people wherever they may be found, disregarding geographic distribution. In the short run, choosing candidates wholly at large might bring in a higher average of students, he admitted, but this would be offset in the long run by the stimulation that the state quota system would give, to teachers and school authorities in the less favored states, to do the right thing by their crops of future scientists.

Floating Novelty Metal Finds Industrial Uses

Spitfire At Work

Reprinted from The Industrial Bulletin of Arthur D. Little, Inc.

► SODIUM, a novelty of high-school chemistry, has become an important chemical. It is a gray metal that can be cut with a knife; it floats on water, and reacts with it to spit fire. In spite of this spectacular characteristic, it can be handled safely industrially and its extreme reactivity has been found useful in many applications. One of the newest of these is a process recently announced by duPont, largest United States producer of sodium, for the descaling of alloy metals.

In high-temperature metallurgical operations a hard, tightly adherent scale forms on the surface of the metal, and must be removed before subsequent processing. The scale is usually removed electrically or by dissolving it in an acid bath, a process known as pickling. The acid, however, removes some of the base metal, a serious matter with expensive stainless and other alloy steels. In duPont's new sodium hydride process, which avoids this loss, the metal bars or other shapes are dipped into a bath of molten caustic soda maintained at about 700° F. This bath contains from one and a half to two per cent sodium hydride, which is formed in small bottomless containers attached to the inside walls of the tanks, by the reaction of hydrogen and sodium metal. The hydrogen is bubbled in at the bottom of the containers and the sodium is added as bricks at the top. The sodium hydride diffuses through

the open bottom of the container into the bath of molten caustic.

The sodium hydride changes the surface scale to loosely adherent metal, and leaves more caustic soda as the by-product of the reaction. The work, still hot, is then dipped into water; steam formed in this quenching blasts off the loose scale. A final dip into acid to brighten the work may be used, but is not essential. Several commercial installations of this process have already been made and others are now planned.

By far the most important use of sodium metal is in the manufacture of tetraethyl lead, the well-known anti-knock ingredient. Although only about 0.04 fluid ounce of tetraethyl lead is used in each gallon of automobile gasoline, the total consumption of sodium in its manufacture totals millions of pounds annually. During the war, demand for tetraethyl lead in aviation gasoline curtailed supplies of both sodium and lead for other purposes.

Another use of sodium is in the manufacture of sodium cyanide, which is used in large quantities in citrus fumigation, in metallurgical operations, and in the manufacture of one type of transparent plastic. Sodium peroxide, used for bleaching textiles and groundwood pulp, is also made from sodium. A new process utilizes this bleach in the production of high-quality paper, as well as of cheap

newsprint, from ground pulp. Since a wide variety of organic chemicals will react with sodium, the demand for it in the organic field is expected to gain steadily. Many pharmaceuticals, including all the "barbital" series, are derived from sodium. It is an excellent conductor of electricity, and wires with sodium cores covered with copper have reportedly been used in Germany.

Molten sodium is finding increasing use as a heat-transfer medium. The sodium-cooled valve has been called the greatest single step toward improved aircraft engine performance. The hollow interior of a steel valve is partially filled with metallic sodium, which melts when the engine is warm. The sodium, agitated by the

valve's movement, carries the heat through the valve stem to the cooling system. Practically all aircraft engines of 300 horsepower or more have sodium-cooled exhaust valves. In America, sodium-cooled intake valves have been used in high-output engines and they have been employed, as well, in German and Italian aircraft motors.

Sodium was first used during the latter part of the nineteenth century in the manufacture of aluminum. It then cost \$50 a pound, and in an effort to reduce the cost of aluminum, the Castner process for obtaining sodium by electrolysis of molten salt was developed. Now sodium made by this process costs 15c a pound, and world production of it during the war was greater than that of tin.

Engine From Thin Sheet Metal

► A NEW 26-horsepower engine for light automobiles, built on a radically new principle from thin sheet-steel stampings instead of heavy forgings and castings and weighing only 59 pounds, has been announced by Crosley Motors, Inc. It is low in first cost, economical to operate, and can drive the new 1000-pound Crosley car at a top speed of 60 miles an hour. At a 35-mile speed it can operate 50 miles on one gallon of ordinary gasoline.

The cylinder walls of the new engine are of chrom-molybdenum steel, and are only one-sixteenth of an inch thick. The engine parts are all stamped from thin metal sheet and tubes crimped together, then braced into a single piece by melting pure copper into all the joints by an hour's

baking in a hydrogen or gas furnace. The entire engine is thus precision-formed, machined to exact dimensions and is ready to go to work. Its cost is a small fraction of that of a standard engine.

The low fuel consumption of the new engine, the makers state, is a direct result of the thin walls which permit efficient cooling of the cylinders. It operates at the high speed of 5,000 revolutions a minute. Its four cylinders are only two and one-half inches in diameter with a two-and-a-quarter inch stroke. The pistons are cast of aluminum alloy and the crankcase is an aluminum casting. The cooling system holds but five quarts of water, but the pump forces 12 gallons of water through the system every minute.

Navy Chief of Research Demands Civilian Control For Atomic Energy

Too Much Security

► "THE NAVY believes that the entire control of atomic energy should be placed completely in civilian hands."

With this repetition of the opinion of his chief, Secretary of the Navy Forrestal, Rear Adm. H. G. Bowen, chief of the Office of Research and Development, speaking at the recent A.A.A.S. meeting at St. Louis, set himself squarely against military control of further research on nuclear fission and its possible uses, with its inevitable over-emphasis on "security."

We can have so much security that progress will be completely stopped or slowed to our great disadvantage, Adm. Bowen declared.

Where there is need for advice and consultation with the military, he continued, the Secretaries of War and the Navy can call upon officers of the Army and the Navy. The function of the military, however, should be strictly limited to the consultative and the advisory . . .

Speaking not for the Navy now, but for myself as a private citizen of the United States, I am particularly apprehensive of any aspect of military control over atomic energy when I view that possibility in conjunction with the proposal to merge all the military, naval and air services in a single department, and under a single Chief of Staff. I believe that of itself the proposed merger plans to put so much authority in the hands of one

individual that it might extend itself into the field of atomic energy and scientific research in general. Then indeed this nation could well be translated from a republic to military dictatorship.

I believe, still speaking as an individual citizen, that there is more than a threat in the proposed merger legislation to place all scientific research under the thumb of a single, professional, military chief. Perhaps you will choose to wait until the legislation is reported to Congress to determine whether there is a foundation for my fear. But I am sure that you will concur in my belief that if control of atomic research and development is placed under military influence, and that if all military authority is lodged in a single, all-services Chief of Staff, then we will indeed have, as I have said, so much security that progress will be completely stopped.

One of the reasons why Adm. Bowen wants to see unhampered research on atomic energy go ahead as rapidly as possible is his hope of eventually seeing it used as a controlled means of power and not solely as a weapon worthy of the Apocalypse. He would like to see ships, merchant ships as well as warships, propelled by small atomic power-plants weighing only hundreds of tons, instead of the thousands of tons now tied up in boilers, turbines and huge tanks of

oil. The space and weight saved could be utilized for cargo in merchant ships, for better protection in war craft. Perhaps the battleship's answer to the atomic bomb is the use of atomic power to make herself invulnerable.

Outside the field of nuclear physics, Adm. Bowen wants to see vigorous Naval research on such things as guided missiles which, he said, "are ushering in a new artillery era." Until atomic-energy propulsion becomes practicable, he hopes to see wider application of the simple, rugged gas turbine, which he believes may mean more to our economy than jet propulsion. Radio, radar and other applications of electronics are another direction for research to take.

One possible super-long-range weapon which the speaker believes to be possible is a two-stage rocket, that is, a big rocket carrying a smaller one, which is launched as the carrier-rocket's fuel becomes exhausted. The Germans, he stated, had a weapon which they called the A-10, which was designed to cross the Atlantic,

and arrive on this side with a one-ton payload of high explosive. Substituting an atomic bomb for the relatively feeble TNT, this would be a most terrible weapon, and one practically impossible to intercept and destroy.

Even ordinary artillery is capable of further improvements, Adm. Bowen said, especially since advances in metallurgy have increased the endurance of artillery liners. Higher powder pressures, behind very slender projectiles carried through the larger bore in a light-weight framework or sabot, may be able to increase velocities, flatten trajectories and lengthen ranges.

Not all scientific advances useful to the Navy are tied up in weapons and defenses against them, however, the speaker pointed out. For efficient operation in war as in peace, machines need mathematics to guide them. And such bewildering mechanical "brains" as the computers at Harvard and M.I.T. are producing tables of immense value in all types of engineering.

Answers to Chem Quiz on Page 31

► SOME ELEMENTS got their names like this:

1. (a) $_{13}\text{Al}$ from alum; (b) $_4\text{Be}$ from the beryl; (c) $_{10}\text{B}$ from borax; (d) $_{14}\text{Si}$ from silex; (e) $_{20}\text{Ca}$ from calx, the heel bone.

2. (a) $_{64}\text{Gd}$ for Gadolin; (b) $_{62}\text{Sm}$ for Samarski; (c) $_{90}\text{Cm}$ for the Curies.

3. $_{41}\text{Nb}$ and $_{93}\text{Am}$ (see page 1 of this issue).

4. (a) $_{66}\text{Dy}$ — hard to speak with;

(b) $_{19}\text{K}$, Cinderella sat among the (pot)ashes; (c) $_{33}\text{As}$, the Arabic name sounded like the Greek *arsenikos* — male; (d) $_{54}\text{Xe}$ — stranger.

5. (a) $_{82}\text{Te}$ from tellus, earth; $_2\text{He}$ from helios, sun; $_{34}\text{Se}$ from selen, moon. (b) $_{80}\text{Hg}$, $_{92}\text{U}$, $_{83}\text{Np}$, $_{94}\text{Pu}$. (c) $_{58}\text{Ce}$, $_{46}\text{Pd}$. (d) $_{15}\text{P}$.

6. (a) $_{89}\text{Ac}$, $_{81}\text{Pa}$, $_{88}\text{Ra}$, $_{86}\text{Rn}$ all refer to rays; (b) $_{56}\text{Ba}$, $_{74}\text{W}$ both mean heavy; (c) $_{36}\text{Kr}$, $_{57}\text{La}$ both mean hidden; (d) $_{35}\text{Br}$, $_{76}\text{Os}$ both mean stinky.

Chemical Things To Do

Write With Beam of Light

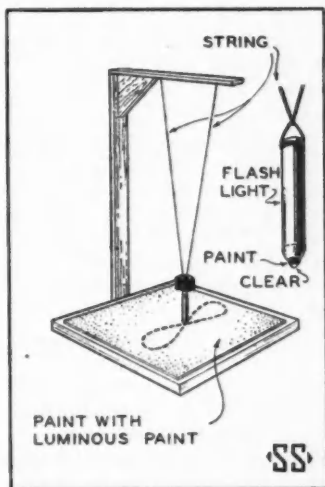
by JOSEPH H. KRAUS

➤ **YOU CAN WRITE ON** a "blackboard" without going near it. After your audience has read your message, the writing will disappear without your touching the board. The trick is done by writing with light on a surface coated with phosphorescent paint, and of course it is better to work in the dark or use only a dim light.

To be prepared to write in the dark, cover a sheet of cardboard with a layer of phosphorescent paint. If you cannot buy the paint in liquid form, just apply a thin coating of varnish to the surface and sprinkle phosphorescent powder on it. A fine strainer is a good way of getting an even coating. Set the coated cardboard aside in a dark room to dry.

Now prepare your flashlight, which will be the "pencil" with which you will write. A small flashlight is best, but any size can be used. To get a narrow beam of light, cover all of the lens with paint, fingernail lacquer or a sheet of black paper. Bare a small circle near the center through which you can project a narrow beam of light.

To trace the message you want to write in the dark, turn on the light and project the flashlight's rays on the coated cardboard. The message will shine brightly at first, then gradually fade until it disappears entirely. The length of time it remains visible will depend upon the brightness of the beam of light and the



length of time the luminescent paint is exposed to the light as well as the quality of the paint used. It will seem much brighter to your audience if they have been sitting in the dark for 10 or 15 minutes so their eyes are accustomed to the dark.

Trace Designs

Another use for your flashlight and phosphorescent board is to trace the movement of a vibrating or moving piece of apparatus such as a pendulum. It can be used to trace the lovely symmetrical curves known as Lissajous' figures, which result from the motion of a double pendulum.

Set your flashlight as illustrated in

the diagram, suspending it by a string. Pass the two ends of the string through a hole in the center of a weight which should preferably be heavier than the flashlight itself. Attach to a support in such a manner that the two ends of the string are separated to form a V. This gives you the equivalent of two pendulums, the flashlight being one and the weight forming the other.

Turn on the beam of light and start the flashlight swinging by pulling it almost at right angles to the support, but a little to one side. Now the weight will swing at right angles to the support because the V in the string keeps it in that direction.

The flashlight, however, follows a more complicated movement caused by pulling it slightly to one side. The combination of movements will produce characteristic Lissajous' figures. These designs are reproduced without interfering with the movement of the flashlight as the light itself "writes" on the fluorescent paint at a distance from it.

By pushing the weight farther up the string, an entirely new set of designs will be obtained. If you have difficulty in holding the weight in position, just insert a small plug of wood into the hole, thus fixing the weight securely to the string.

New Protein Acts As Iron Storage Depot

► AN UNUSUAL BODY chemical with the specific job of acting as storage depot for iron for the blood was announced by Dr. Leonor Michaelis and Dr. S. Granick, of the Rockefeller Institute for Medical Research, at the meeting of the American Chemical Society in New York.

The chemical is a protein called apoferritin. When it contains iron, it is called ferritin. Neither ferritin nor apoferritin is found in the blood, but ferritin is found in many organs of the body. The ferritin of one animal species is not quite identical with that of another, but within one animal species, it is the same whether derived from liver, spleen, bone marrow or blood.

Apoferitin is a novel type of protein, differing from all other protein compounds of the organism. The iron it stores is rather special, too, in

that its magnetic property or susceptibility is of a magnitude not found in any other of the normally occurring iron compounds of the living organism and extremely rarely in iron compounds in general.

The role of apoferritin, the scientists reported, is to store the iron from food or from blood cells used up by age and decay and to make the iron available for manufacture of fresh hemoglobin. Hemoglobin is the red coloring matter of the blood which has the vital role of carrying oxygen throughout the body.

"Why a particular, specific protein is needed to accumulate iron for storage remains a puzzling problem," the scientists stated. "In any case the iron of ferritin accounts nearly quantitatively for all of the iron of the organism which is not a blood pigment or a derivative of such."

**Second of Three Parts:
State Department Report**

International Atomic Control

Problems of control of atomic energy and other weapons of possible mass destruction were the subject designated for study by the Committee on Atomic Energy set up by the Secretary of State James F. Byrnes, on January 7, 1946. Under Secretary of State Dean Acheson was the chairman of this committee, whose other members were Dr. Vannevar Bush, Dr. James B. Conant, Maj. Gen. Leslie R. Groves, and John J. McCloy. The committee named a board of consultants who could devote full time to considering how international control of atomic power could be made to work.

Members of the Board of Consultants were: David E. Lilienthal, of the Tennessee Valley Authority, Chairman; Chester I. Barnard, New Jersey Bell Telephone Co.; Dr. J. Robert Oppenheimer, California Institute

of Technology and University of California; Dr. Charles Allen Thomas, Monsanto Chemical Co.; and Harry A. Winne, General Electric Co. On March 29 the report of this Board of Consultants to the Atomic Energy Committee was made public by the Secretary of State.

In its April issue, *Chemistry* reprinted the first section of the Report, which states the problem of international control. In this issue the second part, setting forth the plan by which adequate international control can be combined with full development of the research side of the problem, is reprinted in full. In the June issue we will present the Consulting Board's schedule for transition from national control of the atomic energy plants of the U.S.A. to international control of all atomic energy problems.

A System of Safeguards

➤ AT THE OUTSET of our inquiry we were preoccupied with some way of making an inspection system provide security. This is a preoccupation that is apparently common to most people who have seriously tried to find some answer to the extraordinarily difficult problem presented by the atomic bomb. But as day after day we proceeded with our study of the facts concerning atomic energy, and reflected upon their significance, we were inescapably driven to two conclusions: (a) the facts preclude any

reasonable reliance upon inspection as the primary safeguard against violations of conventions prohibiting atomic weapons, yet leaving the exploitation of atomic energy in national hands; (b) the facts suggest quite clearly a reasonable and workable system that may provide security, and even beyond security, foster beneficial and humanitarian uses of atomic energy.

What should be the characteristics of an effective system of safeguards:

It may be helpful to summarize the characteristics that are desirable and indeed essential to an effective system of safeguards; in other words, the criteria for any adequate plan for security.

a. Such a plan must reduce to manageable proportions the problem of enforcement of an international policy against atomic warfare.

b. It must be a plan that provides unambiguous and reliable danger signals if a nation takes steps that do or may indicate the beginning of atomic warfare. Those danger signals must flash early enough to leave time adequate to permit other nations—alone or in concert—to take appropriate action.

c. The plan must be one that if carried out will provide security; but such that if it fails or the whole international situation collapses, any nation such as the United States will still be in a relatively secure position, compared to any other nation.

d. To be genuinely effective for security, the plan must be one that is not wholly negative, suppressive, and police-like. We are not dealing simply with a military or scientific problem but with a problem in state-

craft and the ways of the human spirit. Therefore the plan must be one that will tend to develop the beneficial possibilities of atomic energy and encourage the growth of fundamental knowledge, stirring the constructive and imaginative impulses of men rather than merely concentrating on the defensive and negative. It should, in short, be a plan that looks to the promise of man's future well-being as well as to his security.

e. The plan must be able to cope with new dangers that may appear in the further development of this relatively new field. In an organizational sense therefore the plan must have flexibility and be readily capable of extension or contraction.

f. The plan must involve international action and minimize rivalry between nations in the dangerous aspects of atomic development.

The facts we have come to think essential, and the elements of our thinking as we moved toward the plan we herein recommend, are set out in this section, in the form of the considerations that are relevant to an effective program for security, and that have led us to devise what we believe is an adequate plan.

The Problem Has Definable Boundaries

► THIS PROBLEM of building security against catastrophic use of atomic energy is not one without boundaries. This is important. For if the fact were that tomorrow or a year hence we might reasonably expect atomic energy to be developed from clay or iron or some other common material then it is apparent that the problem of protection against the misuse of ener-

gy thus derived would be vastly more difficult. But such is not the case. The only scientific evidence worthy of regard makes it clear that in terms of security uranium is indispensable in the production of fissionable material on a scale large enough to make explosives or power. The significance of this fact for effective international control will appear.

As a first step in our work, we undertook a study, with the help of the qualified members of our group, aimed at an understanding of the well-established principles of nuclear physics upon which, among other things, the conclusion is based that uranium is indispensable as the primary source of atomic energy. These scientific principles are not familiar, but they are capable of being appreciated by laymen. Because the specific content of any system of control will be importantly influenced by the scientific principles and facts, we would emphasize the importance of an appreciation of them. For present purposes, we shall state in greatly simplified terms certain conclusions that are drawn from a full technical account of this subject.

Until 1942 the energy which man had learned to control for his useful purposes derived almost exclusively (except for water, wind, and tidal power) from chemical reactions. For practical purposes, chemical combustion was the main source of energy. This energy is the product of rearrangements of electrons in the periphery of atoms and results from the change in *chemical structure* which occurs in the process of combustion.

"Atomic energy," as that term is popularly used, refers to the energy that results from rearrangements in the structure of atomic nuclei of elements. There are very strong forces which hold such nuclei together and account for their stability. The nature of these forces is not adequately understood, but enough is known about their behavior, not only to make it certain that the energy of an atomic

bomb or an atomic power plant comes from the work done by these forces when the structure of atomic nuclei is rearranged, but also to explain one major fact of decisive importance: Only in reactions of very light nuclei, and in reactions of the very heaviest, has there ever been, to the best of our knowledge, any large-scale release of atomic energy. The reasons for this can be given in somewhat over-simplified form.

As to the light nuclei

The forces which hold all nuclear particles together are attractive. When lighter nuclei combine to make heavier ones, and in particular when the lightest nucleus of all, that of hydrogen, is combined with another light nucleus, these attractive forces release energy. This combination of light elements to form somewhat heavier ones occurs in the stars and in the sun; in the sun effectively what happens is that hydrogen nuclei combine to form the more stable nuclei of helium. Almost all sources of the energy used on earth come to us from the sunlight which this great atomic energy plant provides. But the conditions which make this plant possible are very special, and we do not know how to duplicate them on earth; we may very well never learn to do so. They depend on maintaining matter deep in the interior of the sun at very high temperatures—many millions of degrees. The nuclear reactions themselves provide the energy necessary to keep the matter hot; and it is kept from expanding and cooling by the enormous gravitational forces of attraction which hold the sun together and provide a sort of container in

which this temperature and pressure can be maintained. For the foreseeable future the maintenance of such reactions on earth will not be possible; in the immediate future it is certainly not possible.

As to the heaviest nuclei

Although nuclear reactions can be carried out in the laboratory for all nuclei, and although in some cases a given nuclear reaction may release energy even for nuclei of intermediate weight, the properties which make the large-scale release of such energy possible are peculiar to the very light nuclei and to the heaviest. And the very heaviest nuclei have a property shared by none of the other elements. These very heavy nuclei generate energy if they can be caused to split into lighter ones; this unique process is called "fission." Perhaps a dozen nuclear species are known which can be made to undergo fission; under more drastic treatment no doubt the list will be extended. But to make atomic energy takes more than the property of fission. The fission process itself must maintain itself or grow in intensity so that once it is started in a few nuclei a chain of reactions will be set up and a large part of the material will become potentially reacting. The agency which initiates this process is the neutron. In fission neutrons are emitted; and in certain nuclei bombardment by neutrons is enough to cause fission. There are several substances for which this is true, but there is only one substance which occurs in nature with any significant abundance for which it is true—that substance is uranium. Uranium is the only natural substance

that can maintain a chain reaction. It is the key to all foreseeable applications of atomic energy.

One may ask why there are so few materials which undergo fission, and why so few of these can maintain a chain reaction. The reason lies in the fact that only the heaviest nuclei are sufficiently highly charged to come apart easily, and that only the most highly charged of all are sufficiently susceptible to fission on neutron bombardment to maintain a chain reaction. It is not to be anticipated that this situation will be invalidated by further scientific discovery.

A word needs to be said about the role of thorium, which is slightly more abundant than uranium, and for which fission is also not too difficult to induce. Thorium cannot maintain a chain reaction, either itself or in combination with any other natural material than uranium. Nevertheless, it occupies an important position with regard to safeguards. The reason for this is the following: Without uranium, chain reactions are impossible, but with a fairly substantial amount of uranium to begin with and suitably large quantities of thorium a chain reaction can be established to manufacture a material which is an atomic explosive and which can also be used for the maintenance of other chain reactions.

Absolute control of uranium would therefore mean adequate safeguard regarding raw materials. Yet, since any substantial leakage of uranium through the system of controls would make possible the exploitation of thorium to produce dangerous amounts of atomic explosive, provisions gov-

erning thorium should be incorporated in the system to compensate for possible margins of error in the control of uranium. The coexistence of uranium and thorium in some natural deposits makes this technically attractive.

There can be little hope of devising a successful scheme of control unless the problem can somehow be limited to the immediate future, by arrangements that have a reasonable prospect of validity for the next decade or two, and which contain sufficient flexibility to accommodate themselves to inevitably changing conditions. We believe that a system of control which disregards all materials except uranium and thorium satisfies these conditions. Indeed if a successful system of control can be commenced now, based upon these materials, and if the time should ever come when other materials lend themselves to the same activities, it should in fact be far easier to include them within the system,

than it will be to set up the initial control system with which we are now concerned.

Because the constituent raw materials of atomic energy can be limited to uranium and thorium, the control problem is further narrowed by the geological conditions under which uranium and thorium are found, and the fact that at present those elements have only a restricted commercial significance. Although they are distributed with relative abundance throughout the world, and although it is clear that many sources beyond the known supplies will be discovered, it is apparently the view of the authorities that these elements occur in high concentrations only under very special geologic conditions. This would seem to mean that the areas which need to be surveyed, to which access must be had, and which would ultimately have to be brought under control, are relatively limited.

Adequacy of Present Scientific Knowledge

► THERE CAN BE NO question that its dynamic changing quality is one of the dominant features of the present situation in the field of atomic energy. Advances in knowledge must be expected in a constant stream. Does this mean that a system of safeguards is impossible because new knowledge will completely change the nature of the problem from year to year or even month to month? The answer is in the negative:

When the atomic bomb was first used there was a widespread belief that its development involved a few simple, static secrets. As it became

possible for people to learn how rapidly ideas and techniques had changed in this field in the last years, and how many further developments the future seemed to have in store, the original opinion was replaced by another: that we knew very little of the possibilities and limitations of this field and that it was so rapidly changing that no account of the present technical situation would have much validity. This view has been expressed both in the preamble to a pending Bill, which indicates that too little is known of the technical facts to provide a firm basis for political action,

and in such statements as one attributed to a high official, that it would not be long before we could extract atomic energy from common materials such as clay.

Neither the initial view of a static body of knowledge nor the later one of unpredictably rapid change accurately describes the present situation. As the preceding chapter has shown, there is a great deal that we know about nuclear reactions—know solidly, firmly, and with vast, inter-related experimental checks on the soundness of the description. Novelty will of course appear in scientific discoveries, but it will appear for the most part not as a negation of present knowledge but as the result of new types of physical experience made possible by new methods of physical exploration, and in turn requiring new modes of description. This future experience may have something to do with the basic knowledge involved in release of atomic energy, but there is no basis for believing this, and the chances are against it. There is another type of novelty that lies in ingenious applications of the fundamental facts as they are now known. This does not lessen the importance of the underlying facts and of conclusions which can unambiguously be drawn from them.

For the limited but useful objective of devising a system of control valid for the reasonably foreseeable future, we believe the present knowledge in the field of atomic energy is adequate. We know, for example, that uranium occupies a unique role in the production of fissionable substances and that without it atomic explosives cannot

be made. We know that there is no evidence whatever that this situation will soon change. We know that a vast scientific and industrial effort is necessary in order to produce atomic bombs. This is not to say that the effort, however vast, cannot be concealed—although we believe that measures can be taken to reduce this danger. We know that the release of atomic energy does demonstrate the convertibility of mass to energy, but we also know that the familiar example of this physical principle—that the annihilation of a kilogram of any kind of matter is equivalent to all the power consumed in the United States in a period of three months—is a statement of a possibility, the realization of which is so remote that for the purposes of devising a system of safeguards it may be entirely disregarded.

We know, too, that many areas in this field which are now unclear will be clarified by further investigations. Within a few years much more could be learned about atomic explosives. Within a relatively few years the technology of atomic energy power plants will become clearer. It seems likely that before very long we shall have discovered many useful therapeutic and technological applications for the radioactive substances which can be made in the production of fissionable materials. Nor can there be much question that ways will be found to cheapen and simplify the processes involved in the production of the fissionable materials themselves.

But what needs most to be emphasized is that the dynamic quality

which has so excited popular interest must be seen in its proper perspective in relation to the general field of scientific knowledge. The prophecies as to future discoveries must not be permitted to obscure the fact that there are at key places throughout the field of knowledge firm anchor points around which it should be possible to construct an effective and adequate system of control.

In this report it is possible for us to do little more than record our own sense of the soundness of this statement. Those who must assume re-

sponsibility for political action should test for themselves the correctness of our conclusions. This testing will require an examination of difficult and complicated technical facts, but we are confident that the process is one which other laymen with the appropriate help of experts can readily repeat. We are also confident that unless the effort is made it will be impossible to come to grips with the problem of devising political measures to prevent atomic warfare and to promote the beneficent use of atomic energy.

Constructive Applications for Atomic Energy

► To "OUTLAW" atomic energy in all of its forms and enforce such a prohibition by an army of inspectors roaming the earth would overwhelm the capacity and the endurance of men, and provide no security. This conclusion has a further implication in a search for a security system. While suppression is not possible where we are dealing with the quest for knowledge, this thirst to know (that cannot be "policed" out of existence) *can* be used, affirmatively, in the design and building of an effective system of safeguards.

Human history shows that any effort to confine the inquiring human mind, to seek to bar the spirit of inquiry, is doomed to failure. From such efforts comes subversion fraught with terrible consequences: Gestapo, inquisitions, wars. The development of atomic energy is one of a long, long line of discoveries that have their well springs in the urge of men to know more about themselves and their world. Like the jiu jutsu wrest-

ler whose skill consists in making his opponent disable himself with his own thrusts, the designers of a system of safeguards for security should and can utilize for enforcement measures that driving force toward knowledge that is part of man's very nature.

If atomic energy had only one conceivable use—its horrible powers of mass destruction—then the incentive to follow the course of complete prohibition and suppression might be very great. Indeed, it has been responsibly suggested that however attractive may be the potentialities for benefit from atomic energy, they are so powerfully outweighed by the malevolent that our course should be to bury the whole idea, to bury it deep, to forget it, and to make it illegal for anyone to carry on further inquiries or developments in this field.

We have concluded that the beneficial possibilities—some of them are more than possibilities, for they are within close reach of actuality—in

the use of atomic energy should be and can be made to aid in the development of a reasonably successful system of security, and the plan we recommend is in part predicated on that idea.

That mankind can confidently look forward to such beneficial uses is a fact that offers a clue of not inconsiderable importance to the kind of security arrangements that can be made effective.

The difficulty of recruiting enforcement officers having only a negative and policing function, one of prohibiting, detecting, and suppressing, is obvious. Such a job lacks any dynamic qualities. It does not appeal to the imagination. Its future opportunities are obviously circumscribed. It might draw the kind of man, let us say, who was attracted to prohibition squads in years past. Compare this type of personnel with those who could be expected to enter a system under which it is clear that the constructive possibilities of atomic energy may also be developed. Atomic energy then becomes a new and creative field in which men may take pride as participants, whatever their particular role. They are in "on the ground floor" of a growing enterprise. Growth, opportunities, future development—these are the characteristics, let us say of the field of air transport that have made it possible for the airlines to attract a high grade and youthful personnel.

The importance of this fact that atomic energy has beneficial uses as

well as destructive uses, in terms of the attraction of personnel in a security organization will, of course, depend upon the functions given to that organization. If the security organization has not only enforcement but also *development functions*, then this consideration of beneficial possibilities becomes a most weighty one.

What are the beneficial possibilities? We have had the benefit of a thoughtful, unpublished report on the technical possibilities now apparent in this field. This report was prepared for the Secretary of War's Interim Committee on Atomic Energy by a panel of scientists who worked with a large additional group of leading scientists in the field.* The conclusions there stated represent an appraisal of these possibilities, that is, in our opinion, challenging and at the same time balanced and restrained.

In introducing its conclusions the report observes that "We are probably no more able to foresee the ultimate fruits of development than were Faraday's contemporaries to understand what would come of the discovery of electro-magnetic induction." It gives a further sense of perspective in emphasizing that "The unique preoccupation of the war years in the use of atomic energy for military weapons . . . has probably retarded our understanding of other applications." We believe that this is equally true at present.

The report discusses two "great fields" for beneficial use, "the development of atomic energy as a controlled

* This panel included A. H. Compton, E. Fermi, E. O. Lawrence, and J. R. Oppenheimer. Their report was prepared in consultation with S. K. Allison, Zay Jeffries, C. C. Laureisen, I. I. Robl, C. A. Thomas, H. C. Urey, and with the further help of numerous specialists.

source of power" and "the application of radiations and radioactivities to the growth of the sciences and the practical arts." It gives a sober appraisal of each of these possibilities: "It is probable," the report states, "that the exploitation of atomic energy as a tool for research will outweigh the benefits to be derived from the availability of a new source of power." But this new source of power is itself regarded as of great significance, and is thought to be "the most appropriate focal point for the work of the next few years."

"We have examined in some detail [the report continues] the technical problems of making available heat and power on the scale of present world consumption from controlled nuclear reactors. We see no significant limitations on this development, either in the availability or in the cost of the fundamental active materials. We see characteristic limitations and characteristic advantages in atomic power which make us regard it in great measure as a supplement to existing sources, and an incentive to new developments, rather than as a competitor, let us say, to coal or to petroleum products. We see no foundation in current science for the hope that atomic power can be effectively used for light, small portable units such as are required for aircraft and for automotive transportation; but we believe that the development of rather large power units for heat and conversion to electrical energy is a program for the near future; that operating units which will serve to demonstrate the usefulness and limitations of atomic power can be in existence within a

few years, and that only the gradual incorporation and adaptation of such units to the specific demands of contemporary economy will involve a protracted development."

Finally, the report takes up the opportunities which have been opened in the field of research by the prospect of a plentiful supply of radioactive substances as by-products of the manufacture of fissionable materials, a circumstance which it has been said may well be as significant for scientific progress as the ready availability of microscopes for every laboratory.

"It should be understood [the report says] that work specifically focussed on atomic power need not and should not interfere with making available to biology, medicine, chemistry, and physics the radiations and activities characteristic of this field . . . We should not be astonished if the greatest benefit of this program were in fact to lie in therapy for some of the neo-plastic diseases, such as cancer, or in the increased understanding of biological systems or of the realities of the physical world, which will in turn open up new fields of human endeavor."

The full report contains descriptions in more concrete terms of some of these possibilities. We are convinced that in the vigorous exploitation of them lies one of the greatest hopes of developing a successful system of international control.

Under the most favorable conditions, the peril of atomic warfare can be averted only by drawing upon the best human resources of good will, imagination, and ingenuity. All ex-

perience teaches that these resources cannot be tapped except by challenging opportunities. One of the most serious dangers to the promotion of effective international action is the danger that our natural preoccupation with the destructive aspects of atomic energy may blind us to its useful aspects. Upon searching investigation, some of the latter may prove illusory. But if the lessons of past scientific and technological progress mean anything, we also know that many of these opportunities will materialize. We believe that only a system of safeguards which is built around these

hopeful prospects can succeed. We have tried throughout this report to make explicit the connection between a system of safeguards and these opportunities.

Important, perhaps even decisive, in the proposals we put forth in this report is the fact that many of the constructive activities required in the development of atomic energy involve no risks of providing a material basis for weapons of war. This aspect of the matter is dealt with in detail in the section on "Safe" and "Dangerous" Activities.

Elimination of International Rivalry

► IT IS CLEAR that uranium and thorium are materials of great strategic importance to nations seeking to establish for themselves a powerful position in the field of atomic energy. The fact that rich sources of such materials occur in a relatively few places in the world, as compared, for example with oil, creates a competitive situation which might easily produce intolerable tensions in international relations. We believe that so long as nations or their subjects engage in competition in the fields of atomic energy the hazards of atomic warfare are very great indeed. We assume the General Assembly of the United Nations, in setting up an Atomic Energy Commission, had this disturbing fact much in mind.

What is true in respect to the dangers from national competition for uranium is similarly true concerning other phases of the development of atomic energy. Take the case of a controlled reactor, a power pile, pro-

ducing plutonium. Assume an international agreement barring use of the plutonium in a bomb, but permitting use of the pile for heat or power. No system of inspection, we have concluded, could afford any reasonable security against the diversion of such materials to the purposes of war. If nations may engage in this dangerous field, and only national good faith and international policing stand in the way, *the very existence of the prohibition* against the use of such piles to produce fissionable material suitable for bombs would tend to stimulate and encourage surreptitious evasions. This danger in the situation is attributable to the fact that this potentially hazardous activity is carried on by nations or their citizens.

It has become clear to us that if the element of rivalry between nations were removed by assignment of the intrinsically dangerous phases of the development of atomic energy to an international organization responsible

to all peoples, a reliable prospect would be afforded for a system of security. For it is the element of rivalry and the impossibility of policing the resulting competition through inspection alone that make inspection unworkable as a sole means of control. With that factor of international rivalry removed, the problem becomes both hopeful and manageable.

To restate the conclusion: It is essential that a workable system of safeguards remove from individual nations or their citizens the legal right to engage in certain well-defined activities in respect to atomic energy which we believe will be generally agreed to be intrinsically dangerous because they are or could be made steps in the production of atomic bombs. We schematically describe what we regard as intrinsically dangerous steps later (see page 52). Those activities thus classified as dangerous we conclude are far less dangerous when carried on not by competing nations but by an international organization whose obligation it is to act for all nations. They can, in our opinion, be rendered sufficiently less dangerous to provide an adequate measure of security.

We can illustrate the force of these conclusions in a few simple cases.

(a) Take the case of uranium ores. If any nation may engage in prospecting for and mining uranium ore, subject to inspection as to the proper, i.e., peaceful use thereof, inspection is a most difficult thing. But if the *only legal ownership and development of uranium ore* is in the hands

of an international agency manned by and representing all nations, the problem of detection of evasion is, by a single stroke, reduced tremendously. Indeed, we are persuaded that it is reduced to quite manageable proportions in the light of existing knowledge about uranium ore deposits through the world. For then it would be true that not the purpose of those who mine or possess uranium ore but the *mere fact of their mining or possessing it becomes illegal*, and national violation is an unambiguous danger signal of warlike purposes. The very opening of a mine by anyone other than the international agency is a "red light" *without more*; it is not necessary to wait for evidence that the *product* of that mine is going to be misused.

(b) Take another illustration involving the building and operation of a plutonium pile. The product of that operation is a material that can be used for atomic weapons. The product is also useful for power piles. If all such piles are designed and operated exclusively by an international agency, then the building or operation of such a pile or any move in that direction by *any one else* is illegal without respect to the use he says he plans to make of it, and constitutes a plain and simple danger signal calling for action of a preventative character by an international agency.¹ Nor could there be a clearer sign of danger calling for immediate international action or countermeasures than interference with the operation of an international plant.

¹In Section III we discuss what would happen if the international organization should fail or an international plutonium plant should be seized by a nation; we shall not digress from the present point to discuss that here.

We conclude that the international development and operation of potentially and intrinsically dangerous activities in connection with atomic energy would bring the task of security within manageable proportions because of the elimination of the hazards of rivalry between nations. But there is a further advantage to vesting exclusively in an international agency these activities so hazardous to world security. That advantage grows out of the nature of the development of atomic energy itself.

This is a growing and changing field. New advances in technology may be confidently expected. It therefore becomes absolutely essential that any international agency seeking to safeguard the security of the world against warlike uses of atomic energy should be in the very forefront of technical competence in this field. If the international agency is simply a police activity for only negative and repressive functions, inevitably and within a very short period of time the enforcement agency *will not know enough* to be able to recognize new elements of danger, new possibilities of evasion, or the beginnings of a course of development having dangerous and warlike ends in view. There is a striking example of this. The art of atomic weapons is in its infancy and we are quite ignorant of the possibilities in this field. Such ignorance, such uncertainty of such catastrophic weapons, is itself a source of danger, and its continuation, through the prohibition of further study and development, would in our opinion not only be hard to effect, but would itself be dangerous. Yet

the development of atomic weapons can hardly be left to national rivalry.

A further example: The present separation plants for U 235 at Oak Ridge are huge and bulky in the extreme, and use enormous amounts of power. Quite probably this will always be true. But it is not a law of nature. Those in whose hands lies the prevention of atomic warfare must be the first to know and to exploit technical advances in this field.

We have, therefore, concluded that there was an additional reason and a very practical one why a responsibility for the *development* of atomic energy should be vested in the same international agency that has also responsibility for developing and enforcing safeguards against atomic warfare. For unless the international agency was engaged in development activities itself (as, for example, in the design and operation of power piles or in the surveying and exploration of new sources of raw materials) its personnel would not have the power of knowledge or the sensitivity to new developments that would make it a competent and useful protection to the people of the world.

We have therefore reached these two conclusions: (a) that only if the dangerous aspects of atomic energy are taken out of national hands and placed in international hands is there any reasonable prospect of devising safeguards against the use of atomic energy for bombs, and (b) only if the international agency was engaged in development and operation could it possibly discharge adequately its functions as a safeguarder of the world's future.

Such a development function also seems essential in terms of attracting to the international agency the kind of scientists and technicians that this

problem requires, recognizing that a mere policing, inspecting, or suppressing function would neither attract nor hold them.

"Safe" and "Dangerous" Activities

▶ IT IS TRUE that the internationalization of activities intrinsically dangerous to security reduces the hazards in the way of security and does bring into more manageable form the problems of enforcement and the suppression of atomic weapons. If it were necessary, in such a scheme of safeguards, to vest in an international agency a total monopoly as to all aspects of atomic energy, disadvantages would arise so great as conceivably to make the prospect of effective internationalization itself beyond realization. Such an overall grant of exclusive right to develop, operate, and utilize, conferred upon an international agency, would change many of the industrial and economic practices of this country, for example, and would change them quite disadvantageously.

Such a complete international monopoly would be hard to live under. Its restrictive limitations would chafe, and might in time cause serious loss of support to the security purposes that lay behind the proposal itself. Many of the considerations of complexity, irritation, the engendering of suspicion, the encouragement of deceit that we found militated against a system of safeguards based upon national operation and international inspection would to a lesser degree be repeated by such an all-out proposal for centralization.

This problem need not arise. For there are important areas in the field

of atomic energy where there is no need for an international monopoly, and where work may and should be open not exclusively to the international organization, but to private and to national institutions in a quite free manner. These fields are among those of the greatest immediate promise for the beneficial exploitation of atomic energy. They are technically complex and closely related to the central scientific problems. That open and, in some respects, competitive activity is possible in much of the field should go a long way toward insuring contact between the experts of the international organization and those outside it, in industry and in scientific and educational organizations. The same fact should help correct any tendencies that might otherwise develop toward bureaucratic inbreeding and over-centralization, and aid in providing healthy, expanding national and private developments in atomic energy.

The technical facts which underlie the possibility of regarding many developments in the field of atomic energy as safe for national and private exploitation are in themselves rather complex; to the discussion of these we must now turn. These are, of course, activities which, without reliance on the conscious determination of the operators, and with a minimum of control and supervision, are physi-

cally incapable of contributing to the making of atomic weapons.

A word may be in order about our views on what constitute "dangerous activities"—those that, in our opinion, ought to be subject to an international monopoly. It will be appreciated at the outset that this distinction between the "safe" and the "dangerous" can be useful without being completely sharp or fixed for all time.

In our view, any activity is dangerous which offers a solution either in the actual fact of its physical installation, or by subtle alterations thereof, to one of the three major problems of making atomic weapons:

- I. The provision of raw materials,
- II. The production in suitable quality and quantity of the fissionable materials plutonium and U 235, and
- III. The use of these materials for the making of atomic weapons.

Thus we regard the mining and processing of uranium as a dangerous activity even though it must be supplemented by plants and ordnance establishments if atomic weapons are to result. We regard the facilities for making atomic weapons as dangerous even though some control be exercised over the provision of the fissionable material; and we regard the operation of reactors or separation plants which make the material for bombs or which, by relatively minor operational changes, could make the material for bombs, as dangerous even though they in turn would have to be supplemented by supplies of raw material and by installations for assembling atomic weapons.

We need not regard as dangerous either amounts of material which are small in relation to those needed to make a weapon or installation whose rate of production is small in these terms. A further point which will prove important in establishing the criteria for the safety or danger of an operation is this: U 235 and plutonium can be denatured; such denatured materials do not readily lend themselves to the making of atomic explosives, but they can still be used with no essential loss of effectiveness for the peaceful applications of atomic energy. They can be used in reactors for the generation of power or in reactors useful in research and in the production of radioactive tracers. It is important to understand the sense in which denaturing renders material safer. In the first place, it will make the material unusable by any methods we now know for effective atomic explosives unless steps are taken to remove the denaturants. In the second place, the development of more ingenious methods in the field of atomic explosives which might make this material effectively usable is not only dubious, but is certainly not possible without a very major scientific and technical effort.

It is possible both for U 235 and for plutonium, to remove the denaturant but doing so calls for rather complex installations which, though not of the scale of those at Oak Ridge or Hanford, nevertheless will require a large effort and, above all, scientific and engineering skill of an appreciable order for their development. It is not without importance to bear in mind that, although as the art now

stands denatured materials are unsuitable for bomb manufacture, developments which do not appear to be in principle impossible might alter the situation. This is a good example of the need for constant reconsideration of the dividing line between what is safe and what is dangerous.

We would, however, propose as criterion that installations using material both denatured and insufficient in quantity for the manufacture of bombs could be regarded as safe, provided the installations did not themselves make large quantities of suitable material. With some safeguards in the form of supervision, installations in which the amounts of material are small, or in which the material is denatured, might also be regarded as safe; but installations using or making large amounts of material not denatured, or not necessarily denatured, we would call dangerous.

Let us see now what we regard as safe activities this field.

(1) Perhaps the clearest case is the application of radioactive material as tracers in scientific, medical, and technological studies. This is a field in which progress may be expected to be very rapid, and we can see no reason at all for limiting, on grounds of safety, the activities using such tracer materials.

(2) It is easy to design small nuclear reactors which use denatured U 235 or plutonium. These reactors can be operated at a power level low enough to be incapable of producing dangerous quantities of fissionable materials but high enough to provide neutron sources and gamma ray sources of unparalleled intensity. The

material in these reactors is neither in quantity nor in quality significant for bomb production; even if one combined the material from many, no practical method of making weapons would be available. On the other hand, reactors of this kind can and almost inevitably will be designed to operate at so low a power level that they cannot be used to produce quantities of fissionable material which are of military significance. Reactors of this general kind have the following important applications:

- (a) They may be used to make radioactive materials, and as such may be a supplement, and a valuable supplement, to the more dangerous reactors operating at higher power levels; in particular, they can make useful radioactive materials that last too short a time to permit them to be provided from remote plants.
- (b) As a source of radiation, primarily of neutron radiation, such reactors are research tools for physics, for chemistry, and for biology. This may, in fact, be one of the most important applications of the release of atomic energy.
- (c) The high intensity of radiation from such reactors will bring about changes in chemical and biological systems which may be of immense practical value, once they have been understood.
- (3) More marginal from the standpoint of safety, but nevertheless important, is another case of an operation which we would regard as safe.

This is the development of power from the fission of denatured U 235 and plutonium in high power-level reactors. Such power reactors might operate in the range from 100,000 to 1,000,000 kw. If these fissionable materials are used in installations where there is no additional uranium or thorium, they will not produce further fissionable material. The operation of the reactors will use up the material. If the reactors are suitably designed, a minimum of supervision should make it possible to prevent the substitution of uranium and thorium for the inert structure of the materials of the reactors. In order to convert the material invested in such reactors to atomic weapons, it would be necessary to close down the reactor; to decontaminate the fissionable material of its radioactive fission products; to separate it, in what is a fairly major technical undertaking, from its denaturant; and to establish plants for making atomic weapons. In view of the limited amount of material needed for such a power reactor, and of the spectacular character and difficulty of the steps necessary to divert it, we would regard such power reactors as safe provided there were a minimum of reasonable supervision of their design, construction, and operation. If the material from one such reactor (of a size of practical interest for power production) were diverted, it might be a matter of some two or three years before it could be used to make a small number of atomic weapons.

We attach some importance to reactors of this type because they make it possible in large measure to open

up the field of atomic power production to private or national enterprise. It is, in this connection, important to note that the materials required to construct these reactors cannot themselves be produced in installations which we could regard as safe. It is, furthermore, important to note that for every kilowatt generated in safe reactors, about 1 kilowatt must be generated in dangerous ones in which the material was manufactured. Thus if atomic power is in fact developed on a large scale, about half of it will inevitably be an international monopoly, and about a half might be available for competitive exploitation. That is to say, the primary production plants necessary to produce the materials required to construct *safe* power plants will in that process of production produce large amounts of power as a by-product. It is, furthermore, clear that the stockpiling of appreciable quantities of fissionable material suitably denatured, must precede the development of these safe power reactors. We think it fortunate that the actual operation of such reactors will have to await the production of these essential materials, so that there will be time for further study of means by which they may be supervised and their safety insured.

All the above illustrations show that a great part of the field of atomic energy can be opened with relative safety to competitive activity. They also show that the *safe operations are possible only because dangerous ones are being carried out concurrently*. It is not possible to devise an atomic energy program in which safeguards independent of the motivation of the

operators preclude the manufacture of material for atomic weapons. But it is possible, once such operations are undertaken on an international basis, to devise others of great value and of living interest in which safety is no longer dependent on the motivation of the operators.

We have enumerated elements of the large field of non-dangerous activities under (1), (2), and (3) above. Among the activities which we would at the present time classify as those dangerous for national exploitation are the following:

- (4) Prospecting, mining, and refining of uranium, and, to a lesser extent, thorium.
- (5) The enrichment of the isotope 235 by any methods now known to us.
- (6) The operation of the various types of reactors for making plutonium, and of separation plants for extracting the plutonium.
- (7) Research and development in atomic explosives.

Of these activities, (6), as we have indicated, not only plays an essential part in providing active materials, but involves installations capable of generating power.

It should be added in conclusion that to exclude even safe activities from international operation seems

unwise, but these should not be an international monopoly. It would equally be unwise to exclude from knowledge and participation in the dangerous activities experts who are not associated with the international authority. As the next section will show, there are practical means for making this collaboration possible in such a way that security will be promoted rather than impaired. Only a constant reexamination of what is sure to be a rapidly changing technical situation will give us confidence that the line between what is dangerous and what is safe has been correctly drawn; it will not stay fixed. No international agency of control that is not qualified to make this reexamination can deserve confidence.

Summary

1. If nations or their citizens carry on intrinsically dangerous activities it seems to us that the chances for safeguarding the future are hopeless.

2. If an international agency is given responsibility for the dangerous activities, leaving the nondangerous open to nations and their citizens and if the international agency is given and carries forward *affirmative development responsibility*, furthering among other things the beneficial uses of atomic energy and enabling itself to comprehend and therefore detect the misuse of atomic energy, there is good prospect of security.

Synthetic tanning materials made in Switzerland may prove increasingly important in both domestic and foreign trade in postwar days.

The 24-inch natural gas pipeline, stretching 1,265 miles from Texas to Cleveland and Pittsburgh, completed recently to supply war industrial furnaces with fuel, crosses 67 rivers and streams, 274 highways and 62 railways.

Glass Transmits More Light

by MARTHA G. MORROW

► A PARADOXICAL major optical discovery is that a coating on a piece of glass will let more light through. In experiments and war applications, microscopic films have served practically and well.

Now you can buy them, or you soon will be able to:

Eyeglasses without that troublesome double reflection.

Lenses for cameras that drive away the "ghost" images that sometimes haunt photographs.

Lenses for telescopes that will allow astronomers to capture more light from fainter and fainter stars.

Invisible store windows, without reflection, so crystal clear you might walk through them by mistake.

Transparent films a fraction of a wavelength thick are applied to the glass to make it transmit more light. Not just one, but two and even three coatings, each one so thin that it would take a thousand of them to make the thickness of a piece of newspaper, may be deposited upon the glass so that more light will get through. Only one film, however, is used in coating glass for the market today.

Today news camera and projection lenses are being coated to give sharper and clearer photographs and motion pictures in color as well as in black-and-white. Increasing numbers of clock faces, watch crystals, and glass

covering delicate instruments in airplane cockpits and switchboards are being coated to remove reflections. In the sporting field, coating of binoculars and telescopic rifle sights is already standard practice so that targets may be seen better.

The coating now in use, that eliminates almost two-thirds of the reflection from eyeglass lenses is about as hard as the glass itself. Low-reflection coatings of magnesium fluoride made before the war, on the other hand, were not very durable. They scratched easily and were damaged by handling. It was discovery of the fact that the glass itself should be hot when the film is deposited upon it that made coatings of this type commercially practical.

This refinement was supplied in 1941 by Dr. Dean A. Lyon, then at the Naval Gun Factory, Washington, D. C., but the all-important trick is just coming into civilian use. Dr. Lyon found that if the film of magnesium fluoride, long considered the best material to use for such films, was deposited upon glass that had previously been heated to about 200 degrees Centigrade, the resulting film would cling tenaciously to the glass.

Since the film must be deposited in a vacuum, the glass is heated to the desired temperature while the air is being pumped from within the bell jar.

in air-
wards are
ions. In
binocu-
s is al-
t targets

t elimi-
e reflec-
bout as
reflection
e made
r hand,
atched
ndling,
hat the
en the
t made
ercially



► LENSES at the Eastman Kodak Company are shown getting a coating of fluoride 0.000004 inch thick in a vacuum glass bell jar.

lied in
then at
ington,
rick is
r. Lyon
nesium
est ma-
as de-
viously
egrees
would

ited in
to the
air is
ne bell

The lenses are held in a frame about a foot and a half above a small tungsten filament. In one method the powdered magnesium fluoride is placed under the filament. When the desired high vacuum has been attained, the filament is heated. When the magnesium fluoride reaches 1400 degrees Centigrade it vaporizes, the molecules of magnesium fluoride fly off and strike the lenses with such force that they form permanent coatings on the glass. The desired microscopic thickness is reached when the

lenses, viewed from a particular angle, become reddish purple.

After the lenses have been coated on both sides, they are ready for use. Several million pieces of precision optical elements for use in military instruments were coated by this method during the last years of the war.

With ordinary glass about 4% to 6% of the light is lost each time it passes from air into glass or from glass into air. This means that in the case of binoculars, in which the light

crosses boundary surfaces ten times in its passage through the instrument, only 55% of the original light gets through. About 12% of this loss is due to absorption within the glass itself, while the remaining 33% is lost by reflection.

By coating the surfaces with a transparent magnesium fluoride film, the total light transmitted is increased from 55% to an average of 78%. In more complicated instruments this sometimes results in as much as 200% or 300% more light getting through.

It was an English lens designer, H. Dennis Taylor, who over 50 years ago discovered that the amount of light reflected by glass could be decreased. He noticed that lenses which had been exposed to the elements for a number of years and become tarnished with age actually transmitted more light than newly polished ones.

By using various chemicals to leach the glass surface, he succeeded in creating an artificial stain which accomplished the same purpose.

Glass is leached in one or two processes that have been perfected recently. An improved method developed at the Bausch & Lomb Optical Company involves soaking the glass in dilute nitric acid. The acid, attacking the glass, creates a single etched layer.

Dr. F. H. Nicoll of the Radio Corporation of America developed a process which called for exposing glass to the fumes of dilute hydrofluoric acid. This can be applied to big surfaces such as display windows, but oil and grease tend to collect on the surface and must constantly be cleaned with solvents.

In recent years science has struggled

to devise durable films, knowing that in them lay the key to a new world in optics. The foundation for commercial processes originated with Dr. John Strong of the California Institute of Technology. In 1936 he showed that if a coating of calcium fluoride was deposited on an optical surface, it reduced the amount of light reflected from the surface, and increased light transmission by an equal amount.

Dr. C. Hawley Cartwright and Dr. A. F. Turner at the Massachusetts Institute of Technology experimented with other materials.

These physicists showed that the film could be made harder by baking the coated glass in an oven. They also demonstrated that double-layer films could be produced that were more effective in reducing reflection than single layer films.

Not just one, but two microscopic films are used in a process developed by Dr. E. D. Tillyer and Dr. H. R. Moulton of the American Optical Company. Larger surfaces such as automobile windows can be coated by this method as the film does not have to be applied under vacuum. The glass is merely dipped into first one chemical, a layer of which sticks to it, then into a different chemical for its second layer, and baked. The chemicals can also be swabbed or sprayed on the glass. Each film is only a quarter of one wavelength thick.

Glass coated with the two films may be fully as durable as with a single film of magnesium fluoride. The films, which may be put on in a few seconds, can be applied over a larger area than when a vacuum is needed.

ing that
world
r com-
th Dr.
Insti-
show-
fluoride
surface,
reflec-
increased
mount.
nd Dr.
husetts
mented

at the
baking
ey also
films
more
than

scopic
veloped
H. R.
Optical
ch as
ted by
t have
glass
hemi-
then
second
s can
n the
ter of

films
with a
oride.
a in a
ver a
um is

ISTRY



➤ VARIOUS TYPES of lenses, prisms and optical parts are shown on holders at the Bausch & Lomb Optical Company, all ready for the film to be applied under high vacuum.

One of the main advantages of the two-coat process is that the properties of the individual films may be adjusted to produce the most effective layers.

The best and quickest way of applying to glass these films that must be one-quarter of a wavelength of the light to be eliminated, was studied at the Naval Research Laboratory, Anacostia, D. C., where interest was aroused in the use of films on cockpit enclosures in aircraft.

The order in which the two coats are put on determines whether reflection will be increased or decreased. Transparent mirrors, sometimes called semi-reflectors or beam-splitters, may be made in this way.

The use of films a fraction of a wavelength thick to increase the transmission of light is paradoxical for film on a glass surface actually creates more reflections. In addition to the reflection from the top surface of the film, there is also a reflection from the boundary between the film and glass. The latter reflection returns to the top surface of the film where it is again partially reflected. The trick is to utilize these reflections to our advantage.

It can be shown mathematically that when only one film is used if the

optical thickness of the film is made equal to one-quarter of a wavelength of the light to be eliminated, then the reflection from the glass-film boundary will be 180 degrees out of phase with the reflection from the top surface of the film. If the refractive index of the material is less than that of the glass, destructive interference will result. If the amplitudes of the two reflections are equal, they will completely cancel each other and no light will be reflected.

The amplitudes of the interfering waves will be equal only if the index of refraction of the material comprising the film is equal to the square root of the index of refraction of the glass upon which the film is deposited. But no durable material is known that has the low index necessary to completely eliminate reflection.

The refractive index of magnesium fluoride, used in most commercial films today, is too high to eliminate reflection completely when applied to normal glass. In fact, complete elimination of reflection over the entire visible spectrum is theoretically impossible with a single film.

It is in multiple films that lies science's hope of transmitting practically all the visible light and essentially eliminating reflections.

On the Back Cover

► HALF of the glass in the frame in the foreground has been coated with a thin film of magnesium fluoride to increase the amount of light getting through and decrease reflection, while the other triangular half has not. Light from the lamp is reflected from the glass onto the cardboard behind it in the picture: the faint triangle of light was reflected from the coated half while the bright triangle of light was reflected from the half of glass without the invisible film. The picture is by Fremont Davis, Science Service Staff Photographer.

Gold-Plated Molecules And Plastic Casts

New Electron Microscope Tricks

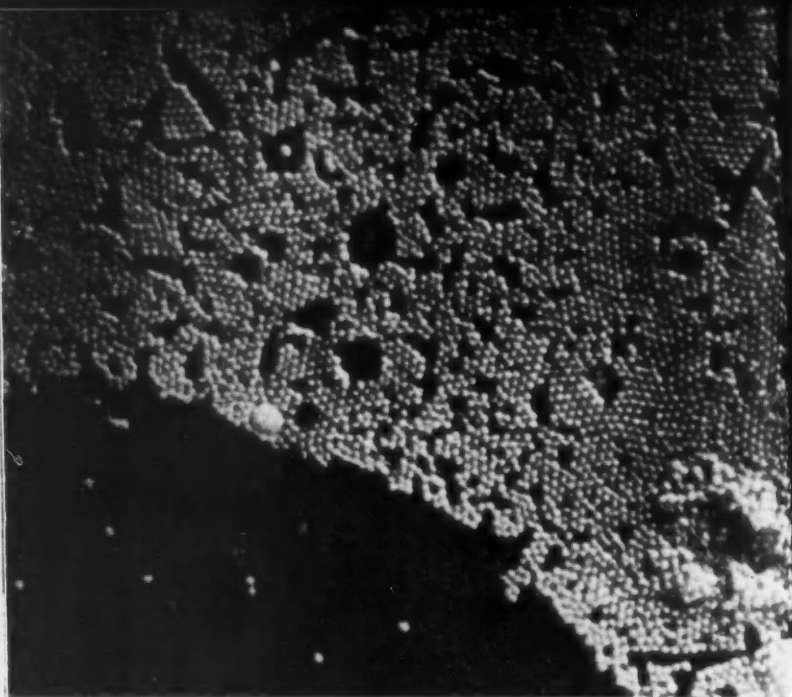
► RED BLOOD CELLS, human hair, fibers and a host of other things in the submicroscopic world can now have their "footprints" caught for study by a new film-plastic technique in combination with the electron microscope.

Scientists were baffled for a time

in trying to make greatly magnified photographs of nylon fibers, sulfadiazine crystals and bacteria because they were too thick to be penetrated by either light waves or electrons. But now, just as FBI experts use moulage to preserve and study footprints of

► RED BLOOD CELLS, magnified 10,000 diameters, show plate-like shapes with deep depressions in the center. This is an electron microscope photograph of a replica of a blood smear. The trick is to cover each cell with a plastic coating. The markings in this plastic film are then permanently "caught" by depositing a thin film of silica upon it.





► *TINY GLOBES in the size range of giant molecules are revealed in cultures of bushy stunt virus photographed through the electron microscope. These minute particles of matter show up when they are gold-plated by the oblique deposit technique.*

criminals, so the impressions of these submicroscopic objects can also be examined.

Little pressure is used in getting a plastic cast of these delicate materials that might easily be crushed beyond all recognition. The markings left by the specimen on the thermoplastic film are permanently recorded by depositing a thin film of silica upon it. It is the silica film that is actually photographed by the electron microscope.

The new technique was first used in studying the surfaces of fibers. The scales and fine markings found in replicas of wool fibers are those characteristic of all fur fibers. Replicas of nylon fibers show long grooves made by imperfections in the spinnerette through which the hot nylon plastic was forced in making the fiber.

How the replicas are made with simple equipment is told in a technical paper in the *Journal of Applied Physics* by Dr. R. Bowling Barnes,

Charles J. Burton and Robert G. Scott of Stamford Research Laboratories, American Cyanamid Company.

Oblique Gold Deposit

► THIN FILMS of gold, deposited obliquely on a submicroscopic specimen, make it possible to obtain with the electron microscope a view of tiny objects otherwise beyond the range of even that instrument.

The lower limit for the electron microscope is determined by lack of contrast, rather than smallness of the object photographed. Biological specimens such as bacteria may be so thin that the electrons are widely scattered, causing lack of definition and a fogged

appearance. An oblique deposit of metal, however, causes the higher elevations of the specimen to cast total or partial "shadows" on the sides or slopes away from the filament which contains the metal to be deposited. This gives a three-dimensional effect to the super-thin specimen, just as a low evening sun makes the mountains stand out in an airplane photograph of the landscape below.

The new technique, which made possible the beautiful photograph of the macromolecules of the bushy stunt virus is reported by Drs. Robley C. Williams and Ralph W. G. Wyckoff, of the University of Michigan, in the *Journal of Applied Physics*.

Stalin Award

► THE FIRST CLASS Stalin award of 200,000 rubles has been made to Vitaly Khlopin, member of the USSR Academy of Science and director of its radium institute, in recognition of his contributions to the science of radioactivity. Dr. Khlopin is internationally known for his research work in the chemistry of radioactive substances and in the use of radioactive preparations as applied in the medical field.

The Radium Institute of the USSR Academy of Science is now one of the world's most progressive institutions in which radioactive phenomena are studied. Its work under Academician Khlopin has greatly influenced the development of the radium industry in the Soviet Union, which uses home-produced raw material.



LANGUAGE IS POWER

... Forge ahead, win special assignments, promotion, better job in global peace time opportunities through ability to speak a foreign language.

MASTER A NEW LANGUAGE quickly, easily, correctly by

LINGUAPHONE

The world-famous Linguaphone Conversational Method brings voices of native teachers INTO YOUR OWN HOME. You learn the new language by LISTENING. It's amazingly simple; thousands have succeeded.

HOME-STUDY COURSES IN 29 LANGUAGES

Send for FREE book—
Call for FREE demonstration

LINGUAPHONE INSTITUTE

64 RCA Bldg., New York 20 • Circle 7-0830

LINGUAPHONE INSTITUTE,
64 RCA Bldg., New York 20, N. Y.
Send me the FREE Linguaphone Book.

Name.....

Address.....

City.....

Language Interested.....

► **AMERICAN** newspapers have played a leading role during the past two decades in informing the world about the progress of science in all fields. **SCIENCE SERVICE**, the institution for the popularization of science and the world's only science syndicate has provided the day-by-day reporting and background of scientific advances that have made this possible. Among the newspapers that have joined with Science Service in this important public service are:

Birmingham (Ala.) Post	Newark (N. J.) Star-Ledger
Phoenix (Ariz.) Arizona Republic	Albuquerque (N. Mex.) Tribune
Alhambra (Calif.) Post-Advocate	Brooklyn (N. Y.) Eagle
Berkeley (Calif.) Gazette	Buffalo (N. Y.) Evening News
Culver City (Calif.) Star-News	Jamaica (L. I.) Queen's Evening News
Pasadena (Calif.) Post	New York (N. Y.) Times
Redondo (Calif.) Breeze	New York (N. Y.) World-Telegram
Riverside (Calif.) Daily Press	Niagara Falls (N. Y.) Gazette
San Francisco (Calif.) News	Rome (N. Y.) Sentinel
San Pedro (Calif.) News-Pilot	Syracuse (N. Y.) Post-Standard
Denver (Colo.) Rocky Mountain News	Troy (N. Y.) Observer Budget
Bridgeport (Conn.) Post	Utica (N. Y.) Observer-Dispatch
Hartford (Conn.) Times	Charlotte (N. Car.) News
New Haven (Conn.) Register	Akron (Ohio) Beacon-Journal
Waterbury (Conn.) Sunday Republican	Cincinnati (Ohio) Post
Washington (D. C.) Daily News	Cleveland (Ohio) Press
Miami (Fla.) Herald	Columbus (Ohio) Citizen
Evansville (Ind.) Press	Dayton (Ohio) News
Indianapolis (Ind.) Times	Toledo (Ohio) Blade
Council Bluffs (Iowa) Nonpareil	Oklahoma City (Okla.) Oklahoman & Times
Wichita (Kans.) Eagle	Philadelphia (Pa.) Record
Covington (Ky.) Post	Pittsburgh (Pa.) Press
Baltimore (Md.) Evening Sun	York (Pa.) Gazette & Daily
Boston (Mass.) Globe	Wilkes-Barre (Pa.) Sunday Independent
New Bedford (Mass.) Standard-Times	Providence (R. I.) Sunday Journal
Springfield (Mass.) Republican	Anderson (S. C.) Independent
Ann Arbor (Mich.) News	Chattanooga (Tenn.) Times
Bay City (Mich.) Times	Knoxville (Tenn.) News-Sentinel
Detroit (Mich.) Free-Press	Memphis (Tenn.) Press-Scimitar
Flint (Mich.) Journal	El Paso (Tex.) Herald-Post
Grand Rapids (Mich.) Press	Fort Worth (Tex.) Press
Jackson (Mich.) Citizen-Patriot	Houston (Tex.) Press
Kalamazoo (Mich.) Gazette	Charlottesville (Va.) Progress
Lansing (Mich.) State-Journal	Lynchburg (Va.) Daily Advance
Muskegon (Mich.) Chronicle	Norfolk (Va.) Ledger-Dispatch
Saginaw (Mich.) News	Richmond (Va.) Times-Dispatch
Rochester (Minn.) Post-Bulletin	Roanoke (Va.) World News
Kansas City (Mo.) Star	Winchester (Va.) Star
St. Louis (Mo.) Globe-Democrat	Seattle (Wash.) Times
Camden (N. J.) Courier-Post	Madison (Wisc.) Progressive
Hackensack (N. J.) Bergen Evening Record	Vancouver (B. C.) Province
Long Branch (N. J.) Daily Record	Toronto (Ont.) Telegram

★ ★ ★

SCIENCE SERVICE

FOR KEEPING UP WITH SCIENCE

Besides CHEMISTRY, Science Service has three other services for individuals. The weekly magazine, SCIENCE NEWS LETTER, reports the latest developments in all fields of science. THINGS of science are sent each month in a distinctive blue box to a limited number of members—exciting new products, unusual specimens, etc. Teachers in high schools and youth leaders are aided in organizing science clubs—a free service. (Then, of course, there are the news and feature services of Science Service available to newspapers and magazines.)

Clip and Mail This Coupon

to CHEMISTRY, 1719 N St., N.W., Washington 6, D. C.

- ☐ Start my subscription to CHEMISTRY for ☐ 1 year, \$2.50
☐ Renew ☐ 2 years, \$4.00
(No extra charge for postage anywhere in the world)

to SCIENCE NEWS LETTER, 1719 N St., N.W., Washington 6, D. C.

- ☐ Start my subscription to SCIENCE NEWS LETTER for ☐ 1 year, \$5
☐ Renew ☐ 2 years, \$8
(No extra postage to anywhere in the world)

to THINGS of SCIENCE, 1719 N St., N.W., Washington 6, D. C.

- ☐ Enter my membership in THINGS for ☐ 6 months, \$2
☐ Renew ☐ 1 year, \$4

to SCIENCE CLUBS OF AMERICA, 1719 N St., N.W., Washington 6, D. C.

- ☐ Send me information on organizing a science club.
☐ Enroll me as an associate of Science Clubs of America, 25c is enclosed.

Name _____

Street Address _____

City, Zone, and State _____

